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COMPARATIVE PHYSICAL GROWTH IN EURAFRICAN AND EUROPEAN JUVENILE ADULTS[1]

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IN connection with a psychological and sociological research project now being carried out on certain children in Industrial Schools and Reformatories, by Dr. M. L. Fick, Psychologist, National Bureau of Educational and Social Research, and Dr. Felix Brümmer, Technical Adviser, Department of Social Welfare, it was considered desirable that the writer should undertake an anthropometrical study with special reference to body measurements in relation to nutrition and growth of the same individuals. Eurafricans are not being included in the psychological and sociological study, but owing to the fact that no anthropometric studies of Eurafricans have been made in South Africa (with the exception of Fisher's studies on the Rehoboth Bastards in S. W. Africa) it is thought that a comparison of the Europeans with the Eurafricans, in the two separate

[1] The detailed biometric constants upon which this paper is based are contained in Tables 5 and 6. These constants are derived from measurements taken at the Tokai Reformatory, Cape Province, South Africa, during December, 1937.

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sections of the Reformatory, would be interesting. In all, measurements of 106 Eurafricans and 163 Europeans are discussed in this paper.

The living conditions in the Institution of both these groups are good, that of the Europeans being superior. Dormitories are well-lit, airy and not overcrowded. The food is ordinary institution food, the approximate composition of which (per boy per day) being as follows:—

	Calories	*Protein (in grams)*	*Fat (in grams)*	*Carbohydrates (in grams)*
Europeans	3400	119 (38% from animal sources)	75 (60% from animal sources)	605
Eurafricans	3200	128 (34% from animal sources)	59 (28% from animal sources)	537

These values are calculated from the official diet scale, from raw foods as purchased. There would be a certain loss in cooking and preparation. Recently (January, 1938) the amount of fat has been increased, as also the vegetables.

The time spent in the institution varies from a few days to about five years. It was not possible to classify the boys according to length of time spent at the Institution.

As far as the accuracy of information regarding the ages of the boys is concerned, that concerning the Europeans would be correct in the large majority of cases, as birth certificates are available for practically all the Europeans. The position regarding the Eurafricans is most unsatisfactory, a large number of them not knowing their own ages. There is as yet unfortunately, no compulsory registration of births and deaths among non-Europeans in South Africa, except, since 1923, in urban areas (Union Publ. Hlth. Rept., 1937). All the Eurafrican juvenile adults considered in this paper were born before 1923. An attempt was made by questioning the colored boys and by consulting the existing records to arrive at their approximate ages. They have been tabulated according to these approximate ages.

The racial composition of the European group is largely Nordic, they being descended in the large majority of cases from the original emigrants from Holland, the British Isles, France (Huguenots), and Germany, who have been coming to South Africa since 1652. There has been no large-scale immigration into South Africa from these countries

during the last thirty years or so. One would consider that these boys are closely similar in racial make-up to "old American" stock. There would also be, in certain cases, a slight admixture of colored blood. The extent of this would be very difficult to determine.

RACIAL COMPOSITION

The following is a synopsis of paragraphs 1-10 of the Report of the Commission of Enquiry regarding Cape Colored Population of the Union (1937) in relation to the racial composition of the Cape Colored people:—

The Cape Colored people are racially of mixed stock. To a large extent they are descendants of slaves, racially heterogenous, consisting partly of Negroes from East Africa and Madagascar, and partly of Malays and various others from the mainland and islands of southern Asia, all mingling at the Cape. A very limited amount of fresh Negro and Asiatic blood has also been added in recent times.

The second constituent is formed by the aboriginal Hottentots (*vide* Dart, 1937, on Bush-Boskop race) who started entering the service of the European settlers who arrived from the middle of the 17th century. The slave-Hottentot infusions are very important constituents of the Cape Colored people.

The third constituent in the racial composition of the Eurafricans or Cape Colored people is a European strain. In the early days Europeans were not averse to racial mixture. The scarcity of European women was an important aetiological factor in the causation of European-slave-Hottentot blending. Since the 17th century there has been an inflow of European blood, mainly from the male side, Dutch, German, French, Portuguese to a small extent, and from the early 19th century onwards, British in increasing numbers.

This process of racial mixture still proceeds to-day, to a relatively small extent on the whole in the smaller centres and in the interior, and more markedly in the larger, especially coastal, centres with large Cape Colored populations.

The slave, Hottentot and European are the main strains present in the Cape Colored, but there is a fourth strain of some importance due to contact with the Bantu. This mixture is taking place mainly in the Eastern and the Northern parts of the Union, where there are large Bantu populations. For further details the original Blue Book should be consulted.

TECHNIQUE AND MEASUREMENTS

As far as technique of measurement is concerned, measurements were made according to the technique of the Iowa Child Welfare Research Station (McCloy, 1936; Meredith, 1936) with the exception of standing height, sitting height and chest depth. For standing height the subjects stood on a scale fitted with a stadiometer rod similar to that used by Franzen (1929). They were told to stand as tall as

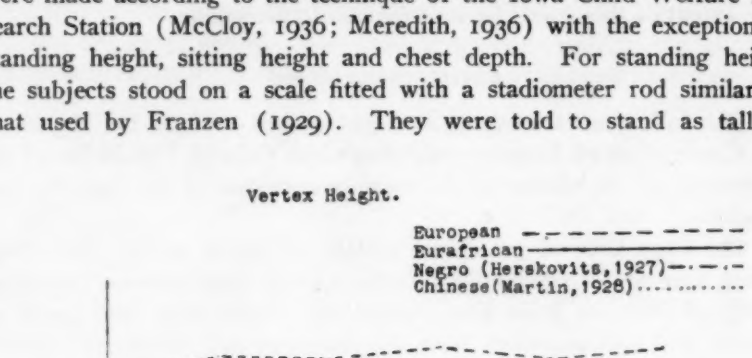

FIG. 1. CURVES FOR GROWTH IN VERTEX HEIGHT FOR EUROPEANS AND EURAFRICANS. DATA FROM AMERICAN NEGROES AND CHINESE ARE INCLUDED FOR COMPARISON

Eurafricans are smaller than Europeans boys at all ages. American Negroes are smaller than South African Europeans at the younger ages, but approach close to the Europeans from 19½ years.

possible, feet together, head in Frankfort plane and eyes horizontal. They did not lean against the rod. For sitting height they sat on the scale, their arms next to legs, hand on knees, the tibiae approximately vertical, knees together. The sacrum and thoracic region of the vertebral column were pressed against the steel stadiometer. The position of the head and eyes were the same as for standing height. One does not consider that the above technique for measuring the heights is the most desirable, but as the scale had to be transported to the Reformatory, and as there was no apparatus for regular measurements at the Institu-

tion the above procedure had to be used. The chest depth was taken at the xiphoid level with large sliding callipers, at right angles to the vertebral column, the mean of extreme inspiration and extreme expiration being taken as the antero-posterior chest diameter.

The circumference of upper arm flexed was taken with arm (left) at right angles to body, forearm supinated and arm muscles fully flexed, fist clenched.

At the Reformatory the colored boys are weighed monthly — in most cases there is an appreciable gain in weight very soon after entering the Institution. This rather large increment in weight points to a state of chronic malnutrition before the boys get the good food and regular hours at the Institution. These monthly weighings will not be utilized in the present study.

All measurements were taken in metric units: vertex height and sitting height accurate to 5 mm., all other measurements accurate to one millimeter. The weight was taken in kilogrammes, accurate to 40 grams. The weights and all measurements were determined on nude subjects.

The somatometric observations include weight, vertex height, sitting height, chest circumference, normal and expanded, circumference of upper arm, relaxed and flexed, chest depth, antero-posterior, at full inspiration and at full expiration, transverse diameter of chest, biacromial diameter, bi-iliac diameter and bitrochanteric diameter.

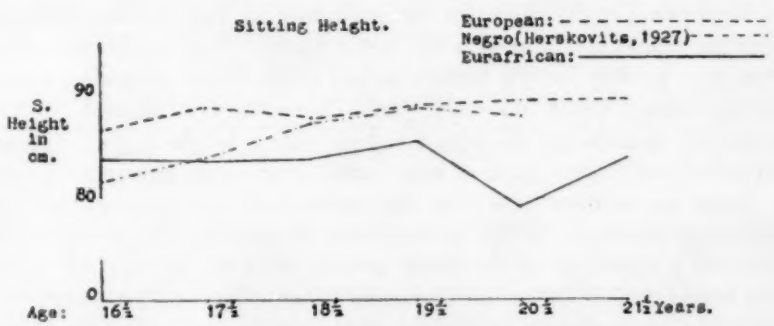

FIG. 2. GROWTH CURVES FOR EUROPEAN BOYS AND EURAFRICANS BOYS IN SITTING HEIGHT. DATA ON AMERICAN NEGRO INCLUDED

The Europeans are bigger in all groups. In Eurafricans the fall at 20½ years is ascribed to paucity of cases in this group. American Negroes have a shorter sitting height than the Europeans in the lower ages, but approach the Europeans very closely from 18½ years.

The statistical constants calculated are the means, standard deviations, standard errors and coefficients of variation for each measurement in the age groups considered. The means were calculated in the usual way, not being grouped, as the numbers are rather small. In the case of the observations on the Coloreds, S.D.'s were calculated without grouping; for the Europeans the S.D.'s were calculated from frequency distributions. Howells (1936) points out that a series of 50 is the smallest number in somatometric measurements of which the sigma's could be accepted as affording any reliable information on group variability. One realizes that measurements on a larger number of comparable individuals would be more desirable, but in the present instance the numbers are unfortunately limited to those individuals in the Reformatory. The arithlog scale (Pearl, 1930; Fisher, 1917) is utilized to compare rates of growth in the various somatometric observations made. The boys are grouped according to ages, e.g. 16 not yet 17 years, 17 not yet 18 years, etc. In the graphs the ages are taken as 16½, 17½, 18½, etc.

The accuracy of the measurements

Although one did not do re-measurements on the juveniles studied with the object of calculating the reliability coefficients of the measurements, one feels that a discussion on accuracy of measurements is essential.

Meredith (1937) discusses the reliability of certain measurements taken on eight- and nine-year-old white males. The coefficients range from .993 to .819 for the measurements made, in the following order: Stature (.993), bi-iliac diameter (.994), bitrochanteric diameter (.982), bicondylar diameter of the femur (.972), sitting height (.974), thoracic circumference (.977), girth of arm (.986), biacromial diameter (.819).

From this evidence it is clear that certain measurements can be made with great accuracy. With the exception of standing and sitting height Meredith's technique is the same as that used in the present study. One would suggest that anthropometrists should test out the accuracy of their measurements by calculating the coefficient of reliability. For instance one does not agree with Orford and Wells (1936) when they state "The evident constancy of the biacromial measurements warrants its use as a standard with which to compare other diameters of the trunk". Their conclusion is reached on the fact that the range of measurements (taken on approximately 100 Bantu females) for the bi-

acromial diameter, is not very large. This conclusion is reached without calculating either sigma or the coefficient of variation. One cannot compare actual ranges in this way — the coefficient of variation must be considered, as this constant, although not quite perfect, is the most accurate measure we have to compare the relative variabilities of measurements. For my European group the C. of V. comes to 5.26 per cent in the case of the biacromial diameter and 2.53 per cent for stand-

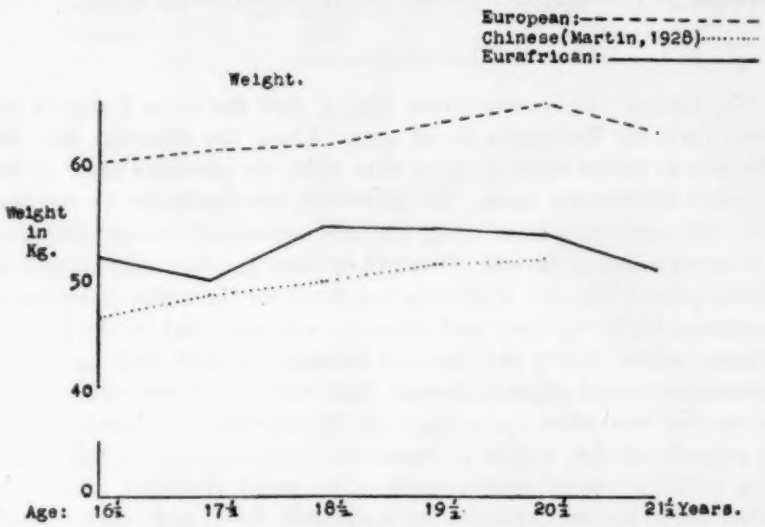

FIG. 3. GROWTH IN WEIGHT OF EUROPEANS AND EURAFRICANS WITH A CURVE FOR CHINESE BOYS FOR COMPARISON

The Europeans are heavier than the Eurafricans at all ages. The same observations are plotted in Fig. 4 on arithlog paper in order to show rate of increase of weight with age. The irregularity of the curves is ascribed to the small number of observations.

ing height, while the range for biacromial width is only 6 cm. (34-40 cm.) and that of standing height, 20 cm. (160-180 cm.). The fallacy of Orford and Wells' argument is obvious on the basis of relative variability alone — but there is another objection to the biacromial width as "standard". It is a very inaccurate measurement as is shown by Meredith — the reliability being the lowest of the skeletal measurements, in spite of the fact that he tried to get a constant measurement by standardizing the position of the scapulae when measuring the children.

As is pointed out by Todd and Lindala (1928) an unreliable measurement might show a very reasonable variability. For instance in my European group the coefficient of variability of the biacromial diameter is less than that of the bi-iliac width — while it is obvious that the bi-iliac diameter is a more stable and reliable measurement than the biacromial diameter. (*Vide* Meredith, 1937). An anthropometric observation can be considered reliable and stable only if (a) the coefficient of reliability is high and (b) if the variability is low.

The measurements

The weight. It is clear from Fig. 3, that the Cape Coloreds are lighter than the Europeans at all ages. Using the criterion, that the difference in means must be more than twice the standard error of the difference between the means, the differences are significant for the ages 17½, 18½ and 19½, these being the only statistically comparable ages. In order to compare the rate of weight increase the data were plotted on arithlog paper (Fig. 4). While the weight of the European group seems to increase fairly regularly and smoothly with age, that of the Colored fluctuates rather widely and does not increase regularly with age. This phenomenon would suggest strongly that extrinsic factors are responsible for the fluctuation (assuming that the sampling is adequate), as it is a general rule that weight increases with increase in age in individuals living under a normal environment. One would therefore ascribe the fluctuation to malnutrition due to inadequate food, and other inimical factors of environment. Fig. 3 also illustrates that Chinese boys (cited by Martin, 1928) are lighter than the Coloreds, while they are of the same height till about 18 years 9 months (Fig. 1) after which the Chinese are taller.

The criterion of weight as an index of nutritional status has received a great deal of criticism during the last few years. One realizes that there are many objections to a height-weight-age, or height-weight standard as an index of nutrition. This question will be discussed more fully in a report which the writer is preparing on the Pretoria Nutrition Survey.

Vertex height and sitting height. In these dimensions the Europeans are also significantly larger than the Coloreds. An interesting phenomenon is observed in comparing my data with that of American Negroes (Herskovits, 1927). While the Negroes grow in height till nineteen and a half years of age it appears (Figs. 1 and 6) that the boys in

both my groups reach their maximum height at about 16½ to 17½ years and do not grow after this age (in height). This is shown more clearly in the arithlog figure (No. 6) than in Fig. 1. The same phenom-

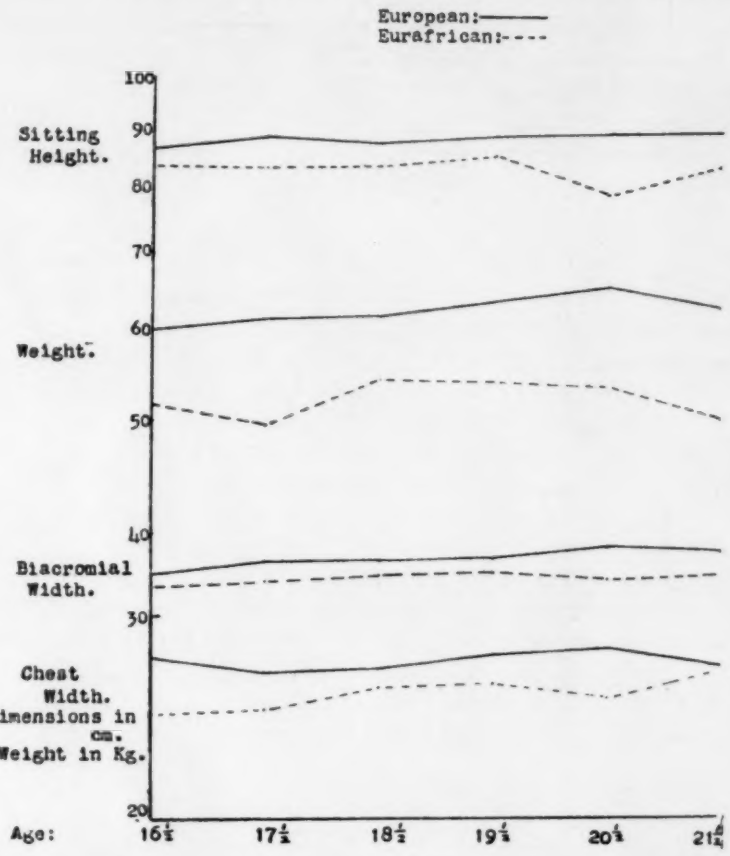

FIG. 4. SITTING HEIGHT, WEIGHT, BIACROMIAL WIDTH, AND CHEST WIDTH AT AGES 16½ TO 21½ YEARS FOR EUROPEANS AND EURAFRICANS

The arithlog grid is used. The variations in measurements are clear from the graph.

enon is observed in the case of sitting height (Figs. 2 and 4). It would seem that maximum height is reached sooner in South African boys than in American Negro boys. This, however, requires confirmation from more data before we can be certain. There is a great fall in the

sitting height of the Coloreds at the age of 20½ (Fig. 2). This is ascribed to the smallness of the number of cases. These four individuals appear to have longer legs than the others as their vertex height

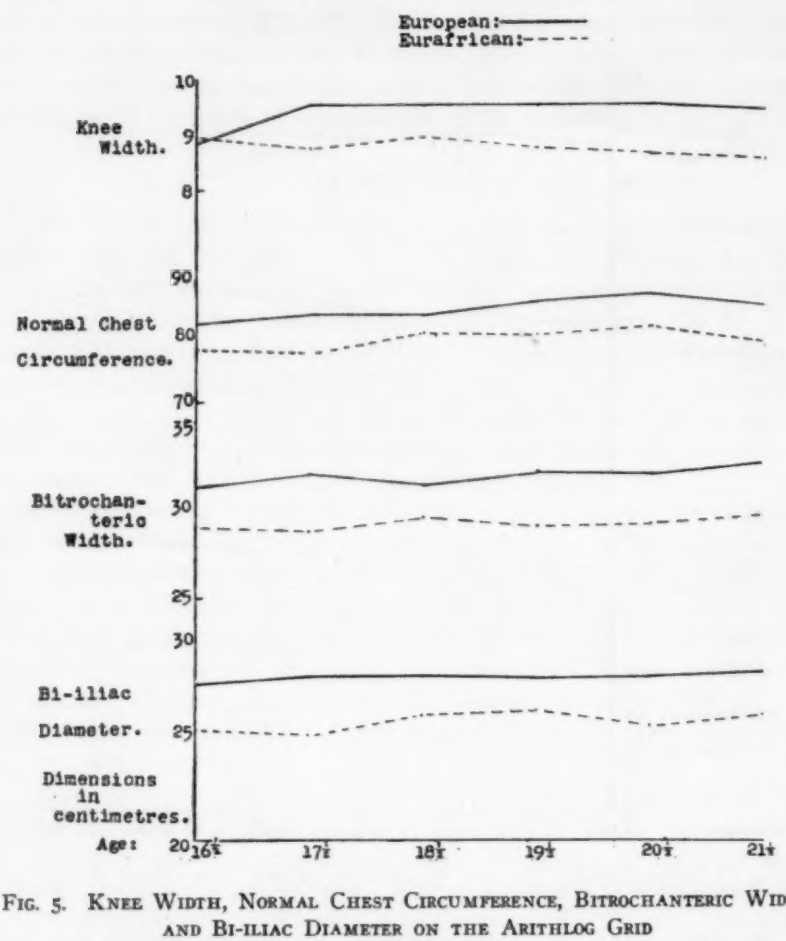

FIG. 5. KNEE WIDTH, NORMAL CHEST CIRCUMFERENCE, BITROCHANTERIC WIDTH AND BI-ILIAC DIAMETER ON THE ARITHLOG GRID

The Europeans exceed the Eurafricans in all measurements except at 16½ years in knee width, when they are about equal in size.

does not show such a fluctuation. As far as the rate of growth in height is concerned it appears to be about the same for the two groups (Figs. 4 and 6). On comparing the Eurafricans with Herskovits' (1927)

data (Fig. 1) it is evident that the American Negro is taller (vertex height) than the Eurafrican at all ages. In sitting height the Negroes are taller than the Eurafricans from the age of about seventeen and a half years.

Dimensions of the chest. The normal chest circumference is significantly larger in the European than in the Eurafrican boys (Fig. 5). In both groups there is a slight increase in circumference up to the age of twenty. If, in both groups, the increase in circumference at maximum expansion be expressed as a percentage of the normal circumference we get the results shown in Table 1.

TABLE 1

Percentage increase in chest circumference on expansion

AGE	EUROPEAN	EURAFRICAN
16	7.7	5.4
17	6.9	5.5
18	7.3	4.9
19	6.4	6.1
20	6.6	4.2
21	6.1	2.0

The expansion of the Europeans is relatively more than that of the Coloreds at all ages compared; i.e. the mobility of the chests of the colored boys appears to be less than that of the Europeans.

The average chest depth, like the circumference (Figs. 5 and 6) increases slightly and regularly up to the age of 20½ in both groups. The width (Fig. 4), however, does not increase regularly for the Europeans or Coloreds. For the Europeans it is more at 16½ years, falls a little to 17½ years and then increases fairly regularly to twenty years. In the case of the Coloreds it increases from sixteen and a half to nineteen years, falls a little at 20½ and is bigger again at 21½. One must realize that for the Europeans numbers are small for ages 16½ and 21½, and for the Coloreds, at ages 20½ and 21½. Ignoring these averages the increase is regular.

Measures of width of body. Biacromial width, bi-iliac width, bitrochanteric width and knee width. In all these dimensions the Europeans are significantly larger for comparable ages (17½, 18½ and

19½). In both groups the biacromial diameter increases with age, although very slightly (Fig. 4). The same may be said of the bi-iliac width of the Europeans (Fig. 5), but in the case of the Eurafricans there is a rather marked irregularity of growth. The increase in growth of the bitrochanteric width is not very regular for both groups (Fig. 5). As far as knee width is concerned it seems that the Europeans reach

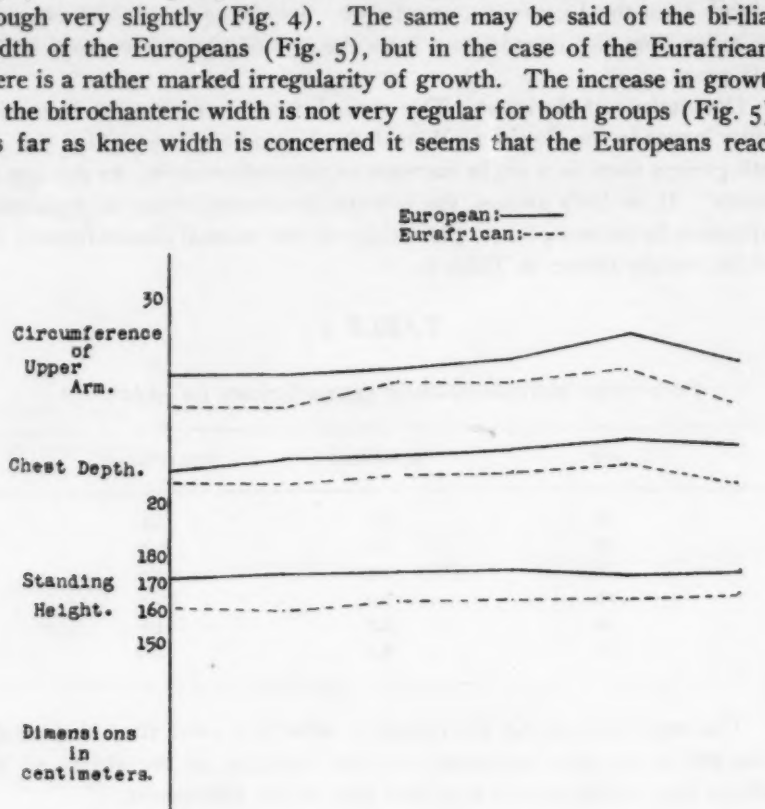

FIG. 6. CIRCUMFERENCE OF UPPER ARM GIRTH (UNFLEXED), CHEST DEPTH (MEAN OR FULL INSPIRATION AND FULL EXPIRATION) AND STANDING HEIGHT FOR EUROPEAN AND EURAFRICAN BOYS

The Europeans are bigger at all ages.

the maximum growth at 17 years, while in the case of the Colored boys the knee width falls from 18 to 21 and is irregular for the ages 16 to 19. In all these dimensions the Europeans are significantly bigger, except in the case of biacromial diameter, where, at the age 19, the difference is not significant.

Circumference of the upper arm, flexed and unflexed. In both groups there is a definite increase in unflexed arm girth from the ages 17½ to 20½. (Fig. 6). It is interesting to note that while the difference between European and Colored in normal arm girth is significant at ages 17½ and 19½, it is not so at 18 years. Nor is there a difference between the flexed circumferences of the two groups at 18½ years. Also, there is no significant difference in the amount of expansion of the muscles of the upper arm on flexion, between the two groups. Comparing the increase of girth on flexion, expressed as a percentage of the normal girth, we obtain the results shown in Table 2.

TABLE 2

Percentage increase in arm girth on flexion

AGE	EUROPEAN	EURAFRICAN
16	8.9	9.9
17	9.3	10.8
18	10.7	10.9
19	9.4	9.4
20	9.3	9.0
21	10.6	13.2

The relative increase in muscle girth is more for the Eurafricans, except at age 20½, than it is for the Europeans. One would suggest that this phenomenon is due to the fact that the Eurafrican boys start hard manual work at a far earlier age than the European, and that their musculature is developed, perhaps at the cost of growth in general size. In this connection a dynamometer study of the actual muscular strength of these two groups would be very interesting.

THE VARIABILITY OF THE TWO GROUPS

The material in the available literature which agrees most closely with my material is Fischer's (1913) work on the "Boer-Hottentot" Rehoboth Bastards. Fischer's original publication not being available, I am citing from Wagner (1932).

Fischer concludes that "σ" and "v" (coefficient of variability) are not reliable as measures of variability. Wagner points out that Fischer's

classification of the material into a "Hott-group", a "Eu-group" and a "middle group" would lead to a decreased variability in each of the groups as compared with the group as a whole. Theoretically the F_2 generation or hybrids, should be more variable than the F_1, or the original "pure" lines crossed. Fischer realizes that his hybrids are far from being homogeneous, thus supporting the theory of greater variability in hybrids, and yet then divides them into four groups, including one of whose ancestry nothing is known. Wagner calculates the "v" of the whole hybrid group with the result that the mean "v" has increased and has also increased for ten of the individual fourteen characters measured, compared with the "middle group". Comparing "v" of the hybrids with that of 100 males from Baden (also from Fischer) Wagner finds, for the most part, a greater variability for the hybrids.

In the following tabulation the comparable coefficients of variability in Fischer's data and my own, for certain characters, are shown:—

Observation	*Rehoboth males*	*Male Badeners*	*Eurafricans*	*S. A. Europeans*
Weight.....	...	...	11.56	9.42
Vertex height.....	4.14	2.31	3.65	2.53
Sitting height.....	3.90	...	4.58	3.49

In the above observation the hybrids show greater variability than the Europeans who may be regarded as a relatively pure strain in both cases, the South Africans possibly being slightly more heterogenous than the Badeners.

Davenport (cited by Wagner, 1932) points out that if two reasonably "pure" parent races are crossed, the variability of the hybrids will be greatest in the characters which differed most widely in the parent races. Let us apply this theory to my data. It would be reasonable to assume that the Cape Coloreds are predominantly a mixture of Europeans and small-sized people such as the Bush-Boskop race (Dart, 1937), slaves, Malays, etc.

Comparing the average variabilities of the two groups (Tables 3 and 4) one finds that the Coloreds are more variable in weight — the variability being most probably increased by the factor of malnutrition to which the Coloreds are more exposed before entering the Institution than the Europeans — and also in arm girth. The factor of malnutrition would also increase the variability in the girth of the muscles.

But the growth of the skeleton is only affected by very gross malnutrition, especially growth in height being made at the expense of the other organs (Roberts, 1935). It is therefore suggested that probably the greater variability in height, vertex and sitting, chest width, bi-iliac width and bitrochanteric width in the Coloreds is due to their hybrid racial composition.

TABLE 3

Colored variability more than Europeans

MEASUREMENT	MALE COLORED C. of V.	MALE EUROPEAN C. of V.
Weight	11.56	9.42
Standing height	3.65	2.53
Sitting height	4.58	3.49
Upper arm unflexed	6.82	6.68
Upper arm flexed	6.57	6.08
Chest width	5.27	5.10
Bi-iliac width	5.94	5.81
Bitrochanteric width	4.70	4.45

TABLE 4

Colored variability less than European

MEASUREMENT	MALE COLORED C. of V.	MALE EUROPEAN C. of V.
Chest circumference (normal)	4.20	4.40
Chest circumference (expanded)	3.97	4.34
Chest average depth	5.37	5.71
Biacromial width	4.48	5.26
Knee width	3.94	4.38

That the Bush-Boskop race (Dart, 1937) is small of stature is well-known. Seiner (1912, quoted by Dart) found adult males to be 155.4 cm. in height, while Dart finds the average figure for adult males to be 155.8 cm. Also in dimensions such as biacromial width (33.0 cm.)

bicristal diameter (23.4) and bitrochanteric diameter (27.4) the adult Bushmen males described by Dart are smaller than the Coloreds. S.D.'s and C.V.'s are not available from Dart's data.

It is interesting to note, however, that in chest circumference (normal and expanded) and in chest depth the Coloreds are less variable, than the Europeans. Dart states that the dimensions of the male Boskop chest corresponds with the adult European, with the exception that the transverse diameter is reduced, the chest being therefore more primitive. In my data also the chest width is more variable in the Coloreds, suggesting this as a definite point on which the original stocks making up the Cape Coloreds differed. Dart's evidence also suggests that the variability in chest circumference and chest depth is not increased in the hybrids because the parent stocks did not differ very much in these characters.

The variability of the biacromial diameter is less for Coloreds than for Europeans, as also the knee width. It would appear, according to the interpretation of variability as suggested by Davenport, that these characters were not very great points of difference in the original stocks. Out of thirteen characters measured, the Eurafricans are more variable in eight.

Wagner (1932) points out that the Rehoboth women show a great variability, much greater than that in Norwegian women (from Schreiner, 1924) in the lower-arm/upper-arm index, among other indices. He suggests that it is probably in length of lower arm (and of hand) that the original Hottentots and Boers varied most. Drennan (1930) points out that the Negro radius is relatively and absolutely longer and therefore more simian, than that of the European, while the Bushman is intermediate between the Negro and European. This therefore fully supports the contention of Wagner. Unfortunately we do not have "v's" for comparison of these characters.

It should be noted, in connection with the so-called "Bushmen" and "Hottentots" that it is better to call them the Bush-Boskop race (Dart, 1937) or Khoisan (Schapera, 1930) as it is becoming increasingly evident that they are not two racial groups but are themselves hybrids. I have compared the Cape Coloreds with the Khoisan because it appears to me that the Eurafricans are mainly a mixture of European-Khoisan, with smaller infusions of other blood. Dart's interesting monograph should be consulted for more details about the Bush-Boskop people.

TABLE 5

Measurements of Tokai Coloreds

(All dimensions in centimeters, and weights in kilograms)

AGE (years)	16						17					
	No.	M	S.D.	S.E.	C.v.	Range	No.	M	S.D.	S.E.	C.v.	Range
Weight	18	51.8	5.91	1.39	11.41	40.92- 62.88	33	49.64	6.16	1.07	12.64	32.08- 65.60
Standing height	17	162.2	6.13	1.49	3.69	153.0 -171.0	33	160.8	6.90	1.20	4.29	145.5 -183.0
Sitting height	17	83.6	3.84	0.93	4.59	74.0 - 89.0	33	83.2	3.83	0.67	4.60	75.0 - 92.5
Chest circumference												
(1) Normal	17	77.7	2.91	0.71	3.75	73.4 - 84.0	33	77.0	3.75	0.65	4.87	73.0 - 84.5
(2) Expanded	17	81.9	3.17	0.77	3.87	77.0 - 88.2	32	81.2	3.73	0.66	4.59	75.4 - 92.0
Circumference of upper arm												
(1) Relaxed	17	24.3	2.23	0.54	9.14	21.0 - 27.7	33	24.2	1.41	0.25	5.83	20.4 - 26.8
(2) Flexed	17	26.7	2.55	0.62	9.55	21.6 - 30.5	33	26.8	1.31	0.23	4.89	22.7 - 28.9
Flexed-relaxed	17	2.4	0.71	0.17	29.6	0.6 - 3.8	33	2.6	0.63	0.11	24.23	1.5 - 4.4
Circumference of abdomen	18	67.3	3.50	0.82	5.20	61.1 - 73.0	33	67.3	3.24	0.56	4.81	61.5 - 77.0
Chest depth												
(1) Full inspiration	18	21.8	1.83	0.43	8.39	19.5 - 26.9	32	21.6	1.35	0.24	6.25	19.0 - 24.4
(2) Full expiration	17	20.2	1.09	0.26	5.39	18.9 - 22.2	32	19.9	1.14	0.20	5.73	17.5 - 23.0
Average depth	17	20.9	1.32	0.32	6.31	19.3 - 24.5	32	20.8	1.16	0.21	5.58	18.45- 23.7
Chest at widest part	18	24.7	1.84	0.43	7.45	20.3 - 29.0	31	24.9	1.10	0.20	4.42	22.7 - 26.8
Biacromial width	17	35.8	1.10	0.27	3.07	33.6 - 37.9	33	36.2	1.61	0.28	4.45	33.0 - 39.5
Bi-iliac width	17	25.0	1.41	0.34	5.64	21.7 - 27.2	31	24.7	1.37	0.25	5.55	21.5 - 27.8
Bitrochanteric width	17	28.9	1.38	0.33	4.77	27.3 - 31.4	31	28.6	1.32	0.24	4.62	26.0 - 32.1
Knee width	18	8.9	0.41	0.10	4.61	8.0 - 9.7	30	8.7	0.42	0.08	4.83	7.9 - 9.8

TABLE 5 (*Continued*)

AGE (years)	18						19					
	No.	M	S.D.	S.E.	C.v.	Range	No.	M	S.D.	S.E.	C.v.	Range
Weight	26	54.4	6.16	1.21	11.3	41.78- 66.46	19	54.15	5.9	1.35	10.89	41.40- 64.36
Standing height	26	164.1	7.68	1.51	4.7	152.5 -186.5	18	163.9	3.17	0.75	1.93	156.5 -175.0
Sitting height	26	83.5	3.11	0.61	3.72	73.5 - 88.0	19	85.2	4.59	1.05	5.39	77.5 - 90.5
Chest circumference												
(1) Normal	25	80.1	2.84	0.58	3.61	75.0 - 87.0	19	80.0	3.66	0.84	4.58	72.6 - 85.6
(2) Expanded	25	84.0	3.09	0.62	3.68	77.0 - 89.0	18	84.9	3.17	0.75	3.73	79.0 - 89.5
Circumference of upper arm												
(1) Relaxed	26	25.5	1.36	0.27	5.33	23.0 - 28.0	18	25.4	1.77	0.42	6.97	22.3 - 29.2
(2) Flexed	26	28.3	1.43	0.28	5.06	25.4 - 31.0	18	27.9	1.83	0.43	6.56	25.2 - 31.5
Flexed-relaxed	26	2.8	0.98	0.19	35.0	0.9 - 6.4	18	2.4	0.27	0.06	11.25	0.6 - 4.1
Circumference of abdomen	26	69.8	4.01	0.79	5.74	63.2 - 78.5	19	70.8	3.59	0.82	5.07	65.0 - 76.0
Chest depth												
(1) Full inspiration	26	21.7	0.99	0.19	4.56	20.0 - 23.6	19	21.9	1.37	0.31	6.25	20.0 - 24.4
(2) Full expiration	26	20.5	1.09	0.21	5.32	17.8 - 22.5	19	20.5	0.96	0.22	4.68	18.9 - 22.0
Average depth	26	21.1	0.96	0.19	4.55	18.9 - 23.0	19	21.2	1.07	0.25	5.05	19.45- 23.05
Chest at widest part	26	26.0	0.89	0.17	3.42	23.9 - 27.6	19	26.1	1.51	0.35	5.79	23.9 - 28.3
Biacromial width	24	36.6	1.73	0.35	4.73	30.7 - 39.1	19	36.9	2.09	0.48	5.66	33.3 - 40.1
Bi-iliac width	26	25.7	1.63	0.32	6.34	22.8 - 29.8	19	26.0	1.62	0.37	6.23	22.9 - 29.3
Bitrochanteric width	26	29.5	0.96	0.19	3.25	27.1 - 30.7	19	29.0	1.81	0.42	6.16	27.1 - 32.3
Knee width	26	8.9	0.44	0.09	4.94	7.5 - 9.8	19	8.7	0.12	0.03	1.38	8.1 - 9.6

AGE	NO. OF CASES	WEIGHT	HEIGHT		CHEST CIRCUMFERENCE		CIRCUMFERENCE OF UPPER ARM			ABDOMEN	CHEST DEPTH			WIDTHS				
			Standing	Sitting	Normal	Expanded	Relaxed	Flexed	Flexed-Relaxed		Full insp.	Full exp.	Average depth	Biacromial	Bi-iliac	Bitrochanteric	Knee	Chest at Widest Part
15	3	48.91	158.8	79.5	76.4	81.4	25.9	26.6	2.7	67.2	21.4	20.2	20.8	34.1	25.6	27.9	8.7	25.0
20	4	53.9	163.7	79.0	81.1	84.5	25.8	28.1	2.3	69.9	22.1	20.9	21.5	36.3	25.2	29.1	8.6	25.4
21	3	50.5	165.3	84.8	78.8	80.3	24.2	26.8	2.6	68.0	21.6	19.9	20.7	36.7	25.8	29.6	8.5	25.4

TABLE 6

TABLE 6

Measurements of Tokai Europeans

(All dimensions in centimeters, and weights in kilograms)

AGE (years)	17						18					
	No.	M	S.D.	S.E.	C.v.	Range	No.	M	S.D.	S.E.	C.v.	Range
Weight	28	61.4	6.177	1.17	10.06	50.0 - 74.2	40	61.8	6.528	1.03	10.5	50.0 - 78.0
Standing height	28	173.1	4.492	0.85	2.595	161.9 -181.6	40	172.9	3.98	0.63	2.302	158.8 -189.2
Sitting height	28	88.5	2.646	0.5	2.99	81.3 - 93.3	38	87.5	3.332	0.54	3.808	81.9 - 95.3
Chest circumference												
(1) Normal	28	83.2	3.768	0.71	4.529	75.9 - 89.5	40	83.0	4.25	0.67	5.121	74.3 - 95.6
(2) Expanded	28	88.9	3.815	0.72	4.291	80.0 - 96.8	40	89.1	4.418	0.70	4.958	80.3 -100.3
Circumference of upper arm												
(1) Relaxed	28	25.9	1.7365	0.33	4.291	22.2 - 28.9	40	26.2	1.889	0.30	7.211	22.5 - 30.5
(2) Flexed	28	28.3	1.9225	0.36	6.705	24.4 - 32.1	40	28.9	1.8905	0.30	6.543	25.4 - 33.7
Flexed-relaxed	28	2.4	0.9795	0.19	40.82	0.6 - 3.8	40	2.8	0.8628	0.14	30.81	0 - 4.8
Circumference of abdomen	28	70.8	3.68	0.70	5.198	62.5 - 77.5	40	71.8	3.812	0.60	5.309	63.5 - 85.1
Chest depth												
(1) Full inspiration	27	23.0	1.518	0.29	6.6	20.0 - 25.2	40	23.1	1.429	0.23	6.186	19.7 - 26.1
(2) Full expiration	27	20.8	4.205	0.81	20.21	18.2 - 22.9	40	20.9	1.251	.197	5.985	18.4 - 24.3
Average depth	27	21.91	1.471	0.28	6.714	19.15- 24.05	40	22.3	1.277	0.20	5.797	19.05- 25.15
Chest at widest part	28	26.8	1.394	0.26	5.202	24.7 - 30.0	40	27.0	1.423	0.22	5.27	23.8 - 31.5
Biacromial width	27	37.7	2.045	0.39	5.425	34.5 - 40.8	40	37.7	1.97	0.31	5.517	33.1 - 44.1
Bi-iliac width	28	27.9	1.587	0.30	5.69	25.1 - 32.0	40	27.9	1.57	0.25	5.627	25.1 - 31.8
Bitrochanteric width	28	32.1	1.686	0.32	5.253	29.7 - 38.6	39	31.5	1.281	0.21	4.066	29.1 - 33.7
Knee	28	9.5	0.3868	0.07	4.071	8.8 - 10.1	38	9.5	0.4036	0.07	4.248	8.5 - 10.4

TABLE 6 (*Continued*)

AGE (years)	19						20					
	No.	M	S.D.	S.E.	C.v.	Range	No.	M	S.D.	S.E.	C.v.	Range
Weight	40	63.9	6.867	1.09	10.74	52.1 - 76.2	32	65.6	4.152	.73	6.328	56.2- 74.5
Standing height	40	173.9	5.5	0.87	3.163	161.6 -187.3	32	172.7	3.5324	.62	2.046	160.3-186.1
Sitting height	39	88.8	3.012	0.48	3.392	80.3 - 96.5	32	89.1	3.348	.59	3.757	81.3- 97.2
Chest circumference												
(1) Normal	40	85.3	4.445	0.70	5.212	77.5 - 96.5	32	86.6	2.46	.43	2.841	81.9- 92.1
(2) Expanded	40	90.8	4.874	0.77	5.368	81.6 -100.3	32	92.3	2.805	.50	3.04	84.5- 97.8
Circumference of upper arm												
(1) Relaxed	39	26.7	1.8825	0.30	7.053	23.5 - 30.2	32	28.0	1.614	.29	5.763	22.9- 30.5
(2) Flexed	39	29.3	1.7815	0.29	6.081	26.0 - 32.7	32	30.6	1.5115	.27	4.942	26.4- 33.3
Flexed-relaxed	39	2.6	0.8427	0.13	32.41	0.7 - 5.0	32	2.6	0.6663	.12	25.63	0.3- 3.5
Circumference of abdomen	40	72.7	4.102	0.65	5.643	62.9 - 83.2	31	74.6	2.616	.47	3.506	68.6- 79.1
Chest depth												
(1) Full inspiration	40	23.45	1.431	0.23	6.102	21.2 - 27.2	32	23.8	1.491	.26	6.265	21.3- 27.4
(2) Full expiration	40	20.95	1.192	0.19	5.69	18.8 - 23.3	32	21.5	1.132	.20	5.266	19.3- 24.4
Average depth	40	22.16	1.122	0.18	5.063	20.65- 25.25	32	22.64	1.91	.21	5.26	20.3- 25.9
Chest at widest part	40	27.6	1.641	0.26	5.967	24.5 - 32.0	31	28.0	1.096	.20	3.914	25.9- 30.0
Biacromial width	40	37.9	2.385	0.38	6.294	33.3 - 43.1	32	38.7	1.466	.26	3.788	35.9- 41.6
Bi-iliac width	40	27.8	1.336	0.21	4.806	25.0 - 30.8	32	27.9	1.991	.35	7.137	26.0- 30.7
Bitrochanteric width	40	32.4	1.339	0.21	4.133	29.3 - 35.8	31	32.2	1.406	.25	4.365	28.6- 34.8
Knee	40	9.5	0.5106	0.08	5.375	8.3 - 10.9	31	9.5	0.3618	.06	3.809	8.8- 10.1

AGE	WEIGHT	HEIGHT		CHEST CIRCUMFERENCE		CIRCUMFERENCE OF UPPER ARM			ABDOMEN	CHEST DEPTH			WIDTHS				
		Standing	Sitting	Normal	Expanded	Relaxed	Flexed	Flexed-Relaxed		Full Inspir.	Full Expir.	Average depth	Chest at widest part	Biacromial	Bi-iliac	Bitrochanteric	Knee
16 years (6)	60.1	170.7	86.4	81.9	88.2	25.88	28.1	2.28	71.1	22.38	20.16	21.32	27.6	36.9	27.35	31.3	9.3
Range	53.6-	164.6-	82.9-	79.4-	84.5-	23.5-	25.1-	.3-	67.9-	18.9-	16.7-	17.8-	25.2-	35.3-	25.7-	30.0-	8.5-
	72.8	178.1	89.5	87.9	92.7	28.6	30.5	4.2	78.7	27.0	23.9	25.45	29.6	38.4	29.1	33.0	10.0
21 years (17)	63.0	173.7	89.2	84.8	90.0	26.5	29.3	2.8	72.2	23.5	21.2	22.4	27.0	37.5	28.2	33.0	9.4
Range	57.4-	155.6-	81.6-	79.1-	82.6-	23.2-	26.0-	1.6-	67.3-	21.2-	19.1-	20.05-	21.9-	28.5-	25.1-	30.2-	8.8-
	73.2	186.7	94.9	90.8	101.6	29.5	31.8	3.5	80.6	26.4	25.0	25.7	29.6	40.9	30.8	42.3	10.4

DISCUSSION AND CONCLUSIONS

In this study it is found that the Colored boys are significantly smaller than comparable Europeans, except in upper-arm girth at 18½, the expansion on flexion of the upper-arm musculature, and in the case of biacromial diameter at the age of nineteen and a half. One would be inclined to ascribe the fluctuation in weight and muscle girth in the case of the Coloreds, as compared with the Europeans, as being due to an unfavorable environment, notably malnutrition, as usually malnutrition effects the soft tissues first.

In relation to the skeleton it would seem that the small size is probably due, to a great extent, to hereditary factors. But then again, we cannot be dogmatic. Man has certain hereditary potentialities, but does he not need an optimum environment to develop these qualities fully and completely? Numerous studies (Sanders, 1935) have clearly shown that there has been a tendency for man's stature (and also his weight) to increase since the early part of the nineteenth century. And can this increase in size be interpreted except in terms of an improved environment, better housing, better food, more rest, less hard manual work for the growing child and more facilities for recreation? Brock (1932) finds that in all European countries there has been an increase in average stature during the last 30-50 years, of 2.4 to 3.7 cm. And the causes of this increase? To quote: "Besonders sind wohl drei in Betracht zu ziehen : eiweissreichere Ernährung (zunehmender Fleischverbrauch in allen europäischen Länden während der letzten Jahrzehnte!) weniger körperliche Arbeit, mehr geistige Betätigung".

Even if the Cape Colored boys are small, due to hereditary factors, no one can deny the unpleasant fact of their chronic malnutrition previous to entering the Institution.

In connection with the expansion of the chest in the two groups the Colored boys seem to have less mobility of the thorax. Has this any relationship to the prevalence of pulmonary tuberculosis in the general colored population?

SUMMARY

1. Somatometric measurements of 106 Eurafricans (Cape Colored) and 163 European male juvenile adults are compared.

2. The Europeans are significantly larger in all measurements except in arm girth at 18½ years, biacromial diameter at 19½ years, and increase in girth of upper arm on flexion at ages 17½, 18½ and 19½.

3. It is suggested that the smaller size of the Eurafricans is primarily hereditary, but that chronic malnutrition before coming to the Institution has also played a very important part in stunting their growth.

4. The need for more research in South Africa into problems of race, of growth, and nutrition, especially in man, is stressed.

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AGE OF FATHER AND SURVIVAL OF OFFSPRING[1]

BY J. YERUSHALMY[2]

IT IS difficult to obtain a reliable and accurate measure of reproductive capacity of humans. In general terms, however, it is known that the power of procreation is not constant throughout life. For females, there exists an upper age limit beyond which reproduction terminates; for males there apparently is no upper age limit. There is evidence also that fertility in both sexes declines gradually with advancing age. Some indication of the relationship between age of parents and reproductive capacity is shown in Table 1 reproduced from a paper by Pearl (1).

TABLE 1*

Probability (chance in 100) of annual births in Budapest by quinquennial age groups of father and mother

AGE OF FATHER	AGE OF MOTHER					
	20-24	25-29	30-34	35-39	40-44	45-49
20-24	35.0	27.3	22.8	...	...	...
25-29	40.7	33.9	25.8	22.1	16.0	...
30-34	33.2	30.8	22.7	18.4	7.4	1.8
35-39	31.1	26.0	22.3	17.5	8.7	0.8
40-44	25.0	21.4	17.3	15.7	8.0	1.3
45-49	19.7	18.9	14.1	10.8	5.6	1.1
50-54	...	...	12.5	10.2	3.7	0.4
55-59	...	...	11.2	7.6	3.0	0.3

* Reproduced from Table 10 of Raymond Pearl (1).

[1] From Child Hygiene Studies, Division of Public Health Methods, National Institute of Health, U. S. Public Health Service, and the Division of Maternity, Infancy and Child Hygiene, New York State Department of Health.

[2] The author is indebted to Miss S. Elizabeth Sheerar of the Division of Maternity, Infancy and Child Hygiene of the New York State Department of Health for her assistance in the construction of the tables and charts.

An inspection of Table 1 shows that fertility in females declines continuously with advancing age for every age group of father. In males, fertility is low for the very young fathers, is highest at ages 25-29 and thereafter declines with increasing age. This pattern is evident for every age group of mother.

It is of interest to inquire into the *qualitative* variations in fertility by age of parents. Such inquiry would be concerned with the vitality of the offspring and would require, therefore, a reliable and accurate measure of vitality. It is difficult to obtain an index for qualitative fertility entirely free from the effect of environmental factors. One reasonably adequate index might be expressed in terms of a *pregnancy wastage rate,* i.e., the number of abortions and miscarriages per 1,000 pregnancies. However, it is not readily possible to obtain reliable figures on the number of abortions and miscarriages. Furthermore, such data as may be obtained are complicated by the factor of voluntary termination of pregnancy. Consequently, stillbirth and neonatal mortality rates may be accepted as an index (admittedly crude) of qualitative fertility.

In a previous study (2) the variations of the neonatal mortality rate by order of birth and age of parents were investigated. One table in the above paper which presents neonatal mortality rates by age of parents is reproduced in Table 2. This table is based on over 82,000 births which occurred in New York State, exclusive of New York City, in 1936.

A comparison of Tables 1 and 2 is instructive. The ages of the parents at which fertility is high are those at which the neonatal mortality rates are low and the ages of low fertility are the same for which neonatal mortality is high. Thus the pattern of the neonatal mortality rates by age of parents is generally opposite to that of the fertility rates. This is especially marked with respect to age of father. The neonatal mortality rates by age of father when age of mother is kept constant (the rates along any column) are high for young and for old fathers and low for fathers aged 25-34.

The editor of "The Lancet" in discussing the material given in Table 2 expressed difficulty in accounting for the observation that

> "neonatal mortality for mothers of the same age is high for young fathers, lowest for fathers aged 25-29 and then increases with age of father. Social differences may again play some part or, as Yerushalmy hints, there may be biological implications in the figures, age having some effect on the reproductive vitality of fathers . . . ." (3).

In the same discussion the statement is also made that "social environment probably has less effect upon the incidence of stillbirths than upon the incidence of early mortality."

TABLE 2

Neonatal mortality rates by age of mother and age of father for legitimate births in New York State (exclusive of New York City), 1936*

AGE OF FATHER	TOTAL	AGE OF MOTHER					
		Under 20	20-24	25-29	30-34	35-39	40 and over
Total	30.5	34.2	28.3	25.9	32.4	36.6	47.9
Under 20	37.5	43.1	...	...	...	...	...
20-24	32.9	33.8	31.2	35.3	...	...	...
25-29	25.4	30.1	24.5	24.1	39.4	53.6	...
30-34	29.6		32.6	27.9	29.8	28.1	...
35-39	32.1	41.8	30.3	21.8	34.9	36.1	...
40 and over	37.7		30.5	29.2	31.3	38.0	47.9
Values of P**		.14	.01	.05	.13	.29	...

* Deaths of infants under 1 month per 1000 live births.

** By the chi square method.

Fortunately, the official publications of the Division of Vital Statistics of the United States Bureau of the Census present two separate tables of live births and stillbirths by age of parents (4). By combining the data from the two tables stillbirth rates by age of parents may be obtained. Since the material concerns stillbirths instead of neonatal deaths, the effect of the social environmental factor is reduced. In addition, the very large number of births available yields relatively stable rates.

STILLBIRTH RATES BY AGE OF PARENTS

Table 3 shows the distribution by age of parents of over ten and one-half million live births which occurred in the United States Birth Registration Area in the five year period 1931 to 1935.

TABLE 3

Live births by age of parents, U. S. Birth Registration Area 1931-1935*

AGE OF MOTHER	AGE OF FATHER										
	Under 20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55 & over	Not stated	Total
10-14	2,856	3,567	863	332	173	103	68	50	45	5,602	13,659
15-19	124,311	705,678	250,513	57,641	19,518	6,821	3,088	1,358	1,234	118,329	1,288,491
20-24	24,815	1,098,148	1,335,240	432,005	131,307	42,653	16,054	6,869	4,825	81,819	3,173,735
25-29	1,492	117,032	1,066,030	971,798	370,956	109,946	39,859	14,635	9,611	29,622	2,730,981
30-34	240	10,696	117,301	672,356	617,442	239,279	76,311	27,857	15,558	14,718	1,791,758
35-39	66	1,827	12,545	80,118	415,358	360,177	147,552	45,953	25,116	9,262	1,097,974
40-44	22	316	1,340	5,837	33,005	148,356	118,720	46,218	20,651	2,946	377,411
45-49	7	65	126	368	1,042	3,739	15,258	9,941	5,175	431	36,152
50-54	.....	5	22	42	68	77	69	201	176	13	673
Not stated	257	2,167	2,980	2,577	1,904	1,153	630	281	185	67,807	79,941
Total	154,066	1,939,501	2,786,960	2,223,074	1,590,773	912,304	417,609	153,363	82,576	330,549	10,590,775

* Source: Births, stillbirths, and infant mortality statistics, Table 5, 1931-1935.

The largest number of births occurred to mothers aged 20-24 who had nearly one-third of all the births. Mothers in their twenties accounted for well over one-half of all the births.

Slightly over one-fourth of all the births were to fathers aged 25-29 and nearly one-half of the fathers were between the ages of 25 and 34. The largest number of births in any single subdivision by age of both parents occurred to mothers 20-24 and fathers 25-29. This group accounted for 13 percent of all the births.

When the mother was under 25 years of age the peak of the births occurred when the father was in the age group next higher to the age of the mother while for mothers aged 25 years and over the largest number of births occurred when the two parents were in the same age group.

For over 3 percent of the births the age of the father was not stated while for only three-fourths of 1 percent of the births the mother's age was not known. The proportion of births for which age of father was unknown was extremely high when the mother was very young (40 percent for mothers 10-14 and nearly 10 percent for mothers under 20). This excess is doubtless due to illegitimate births.

Table 4 presents the distribution of stillbirths and stillbirth rates per 1,000 total births (including stillbirths) by age of parents in 5-year age groups. The rates are shown graphically in Figs. 1 and 2. Fig. 1 presents the variation of the rates with age of father in the various subdivisions by age of mother. Fig. 2 shows the variation of the rates with age of mother for the various classifications by age of father.

The total rates by age of mother started high for young mothers (38.4), dropped to a minimum for mothers aged 25-29 (29.9) and increased continuously thereafter with age of mother. The rate for the oldest mothers (60.2) was twice the minimum rate.

The stillbirth rates by age of father presented practically an identical picture. This variation is not due entirely to the correlation between the ages of the two parents, since the same trend is evident when the age of mother is held constant. Thus, for example, for births to mothers aged 20-24 the stillbirth rate was high for the youngest fathers (40.2), decreased with age of father to a minimum for fathers aged 30-34 (26.6), and thereafter increased with age of father to a maximum for the oldest fathers (42.5). This pattern was present for every age group of mother. The rate was a minimum in most rows for fathers aged 30-34. The fact that in the total rate the minimum was recorded for fathers aged 25-29

TABLE 4

Stillbirths and stillbirth rates per 1000 total births, by age of parents.

TABLE 4

Stillbirths and stillbirth rates per 1000 total births, by age of parents.
U. S. Birth Registration Area 1931-1935*

AGE OF MOTHER	AGE OF FATHER										
	Under 20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55 and over	Not stated	Total
	*Number of stillbirths***										
Under 20	5,301	25,830	8,258	1,994	770	273	145	120		9,376	52,067
20-24	1,038	35,447	37,695	11,793	4,138	1,387	575	264	214	6,819	99,370
25-29	4,332		31,166	28,181	11,302	3,674	1,454	586	363	3,021	84,079
30-34	525		4,415	22,528	21,945	9,033	3,059	1,244	752	1,742	65,243
35-39	123		674	3,623	18,511	17,424	7,431	2,465	1,365	1,238	52,854
40 and over		120		367	1,985	9,247	8,689	3,807	1,792	544	26,551
Not stated	24	170	232	179	185	112	75	37	17	10,453	11,484
Total	6,455	66,359	82,536	68,665	58,836	41,150	21,428	8,470	4,556	33,193	391,648
	Stillbirth rates per 1000 total births										
Under 20	40.0	35.1	31.8	33.3	37.6	37.9	43.9	42.8		70.3	38.4
20-24	40.2	31.3	27.5	26.6	30.6	31.5	34.6	37.0	42.5	76.9	30.4
25-29	35.3		28.4	28.2	29.6	32.3	35.2	38.5	36.4	92.5	29.9
30-34	45.8		36.3	32.4	34.3	36.4	38.5	42.7	46.1	105.8	35.1
35-39	61.0		51.0	43.3	42.7	46.1	47.9	50.9	51.5	117.9	45.9
40 and over		59.3		55.5	55.0	57.3	60.9	63.3	64.5	138.3	60.2
Not stated	85.4	72.7	72.2	64.9	88.6	88.5	106.4	116.4	84.2	133.6	125.6
Total	40.2	33.1	28.8	30.0	35.7	43.2	48.8	52.3	52.3	91.3	35.7

* Source: Births, stillbirths, and infant mortality statistics, Table 13, 1931-1935.
** Total stillbirths, including males, females, and sex not stated.

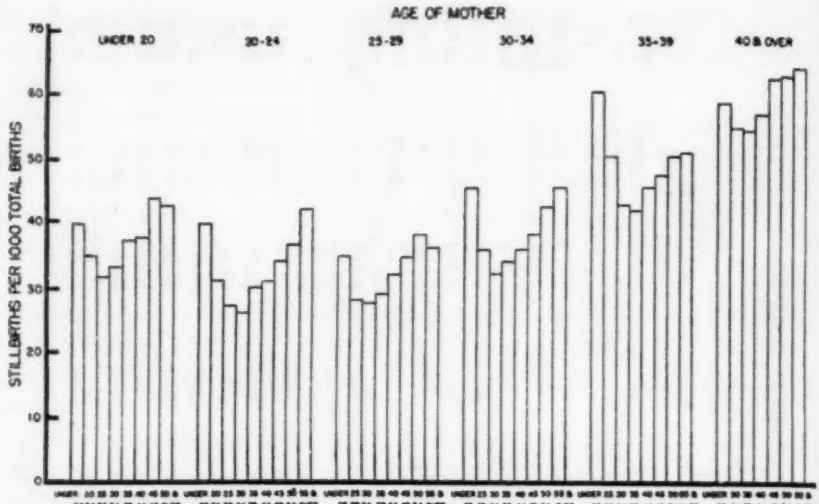

FIG. 1. STILLBIRTH RATES (PER 1000 TOTAL BIRTHS) BY AGE OF FATHER IN THE VARIOUS SUBDIVISIONS OF THE BIRTHS BY AGE OF MOTHER. U. S. BIRTH REGISTRATION AREA 1931-1935

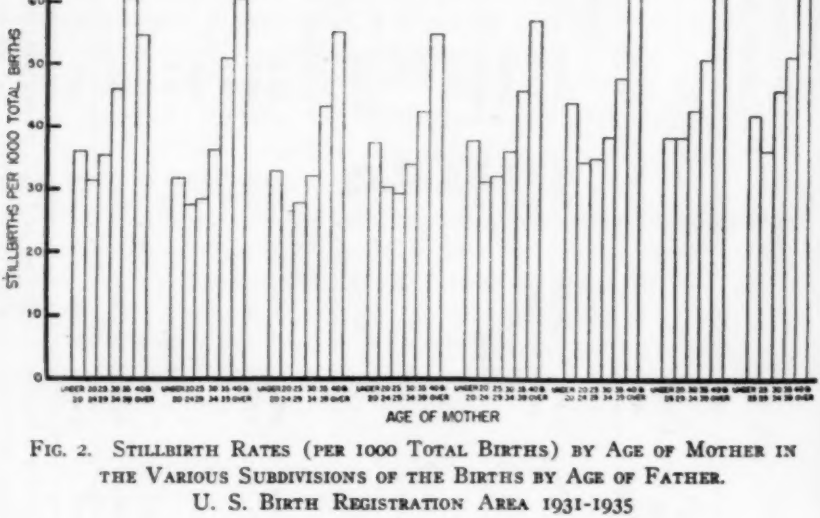

FIG. 2. STILLBIRTH RATES (PER 1000 TOTAL BIRTHS) BY AGE OF MOTHER IN THE VARIOUS SUBDIVISIONS OF THE BIRTHS BY AGE OF FATHER. U. S. BIRTH REGISTRATION AREA 1931-1935

is due to the more favorable distribution of the ages of the mothers for that age group of fathers.

When the rates are followed along any of the columns in the table, that is, when age of father is held constant, the same pattern of the variation of the rates by age of mother is observed. The ages of the two parents are, therefore, shown to be independently correlated with the stillbirth rate. It is noteworthy that the relationship is relatively more marked for young fathers than for young mothers, while in the old ages it is more pronounced for the mothers than for the fathers.

The stillbirth rates were extremely high for those births in which the age of either or both parents was not stated. The high rates for the births for which age of father is not known reflects the known fact that illegitimate births have a higher stillbirth rate than legitimate births. The fact that the rates were high when father's age was known and age of mother not stated is explicable on the assumption that physicians record the statistical information more completely for live births than for stillbirths.

The U-shaped pattern of the variation of the rates with age of parents, that is, the high rates for young and old parents and low rates for the intermediary ages, was present for every subdivision of the ages of the parents except one. The exception was when age of father was not stated. In this case, the young mothers did not show any disadvantage in comparison with the older mothers. The rate was lowest for the youngest mothers and increased continuously with advancing age of mother. It is probable that the age distribution of the fathers of the births to these youngest mothers was more favorable than that of the fathers of the births to the older mothers.

Sex of infant

It is well known that the stillbirth rate is considerably higher for boys than it is for girls. It is, therefore, desirable to investigate whether the variation by age of parents is present irrespective of sex of infant.

The relation of parents' age to the sex ratio (male births per 1,000 female births) has been studied by a number of investigators, and recently by Ciocco (5) who showed that the variations of the sex ratio with age of either parent when the age of the other is held constant are irregular. Only by grouping the parents in very broad age groups (under and over 30 years) is it noticeable that there is a slight decrease

in the sex ratio with age of parents. This decrease is present for either parent also when the age of the other is held constant, as can be seen from Table 5.

TABLE 5

Sex ratios, U. S. Birth Registration Area 1931-1935

AGE OF MOTHER	AGE OF FATHER		
	Under 30	Over 30	Total
Under 30	1057.4	1053.6	1056.1
Over 30	1056.1	1051.5	1051.7
Total	1057.3	1052.4	1054.7

It is obvious that the slight differences in the proportions of males born to parents of various ages are not of sufficient magnitude to be responsible for the differences of the stillbirth rates observed above. That the age of the parents is related to the stillbirth rates of both boys and girls can be seen from Table 6 and Figs. 3 and 4.

The stillbirth rate was 24 percent higher for boys than for girls. The excess in the rate was present for every age group of mother and for every age group of father as well as for every combination of the ages of the parents. However, *the general pattern of the variations of the rates with the age of one of the parents when the age of the other is kept constant is very similar for both sexes.* Likewise, the differences in the rates by age of parents are relatively of the same magnitude for both sexes.

With but few exceptions, the lowest rates for each subdivision of the ages of either parent were recorded for both sexes in the same age groups. The lowest rate for boys (28.6) was recorded for mothers 20-24 and fathers 30-34. The lowest rate for girls (23.4) was recorded in the same age combination of the parents.

PREMATURE BIRTHS

The problem of premature birth is deserving of special consideration: first, because prematurity constitutes the major part of the problem of stillbirths and neonatal deaths, secondly, because a number of these births presumably are due to the fact that the fetus is not strong enough to be

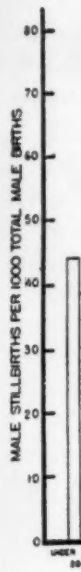

FIG. 3

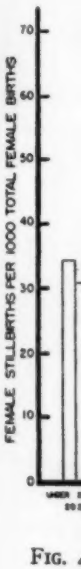

FIG. 4

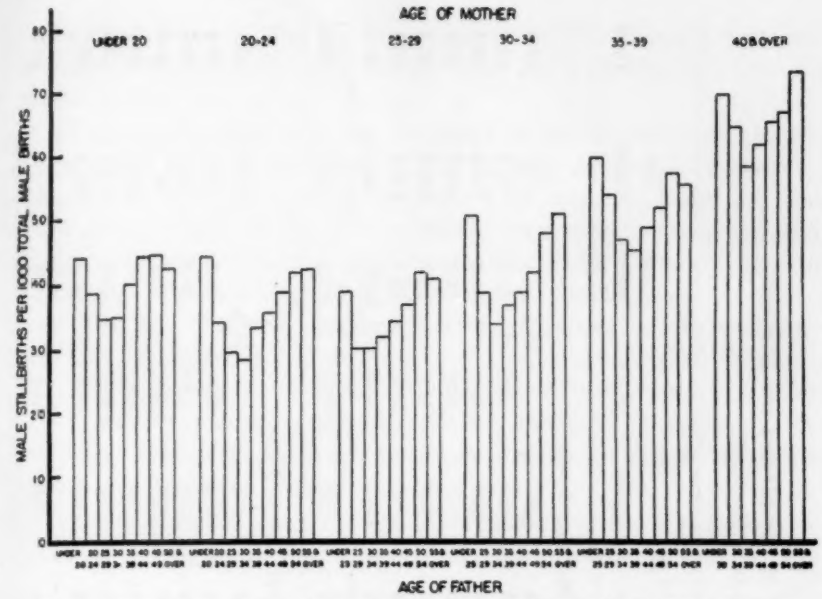

FIG. 3. STILLBIRTH RATES (PER 1000 TOTAL MALE BIRTHS) FOR MALE BIRTHS BY AGE OF FATHER IN THE VARIOUS SUBDIVISIONS OF THE BIRTHS BY AGE OF MOTHER. U. S. BIRTH REGISTRATION AREA 1931-1935

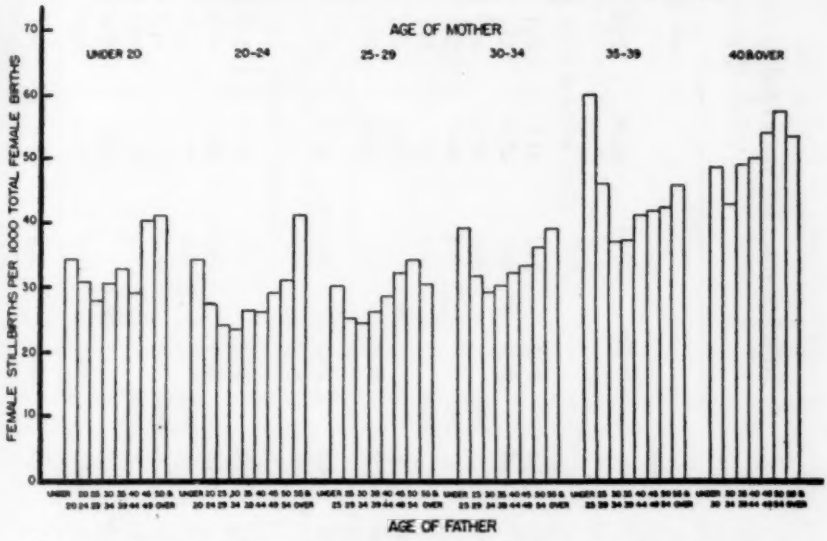

FIG. 4. STILLBIRTH RATES (PER 1000 TOTAL FEMALE BIRTHS) FOR FEMALE BIRTHS, BY AGE OF FATHER IN THE VARIOUS SUBDIVISIONS OF THE BIRTHS BY AGE OF MOTHER. U. S. BIRTH REGISTRATION AREA 1931-1935

TABLE 6

Stillbirth rates per 1000 total births, by age of parents and sex of infant.
U. S. Birth Registration Area 1931-1935

AGE OF MOTHER	AGE OF FATHER										
	Under 20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55 and over	Not stated	Total
	Male stillbirth rates per 1000 total male births										
Under 20	44.3	38.7	34.7	35.1	41.4	44.4	44.6	42.4		75.7	42.0
20-24	44.3	34.2	29.7	28.6	33.6	35.8	39.2	41.8	42.5	81.6	33.0
25-29	39.0		30.6	30.6	31.8	34.5	36.9	41.9	41.2	100.6	32.3
30-34	50.7		39.3	34.2	37.1	38.9	41.8	48.2	51.3	109.1	37.6
35-39	60.2		54.0	47.0	45.7	49.1	52.0	57.5	55.7	122.8	49.3
40 and over		69.3		64.5	58.5	62.2	65.6	67.1	73.3	158.4	65.3
Not stated	107.4	80.1	73.9	65.3	96.1	104.1	125.7	121.8	103.8	146.2	137.3
Total	44.5	36.3	31.1	32.2	38.4	46.3	52.7	57.2	57.9	98.5	38.6
	Female stillbirth rates per 1000 total female births										
Under 20	34.3	30.4	27.9	30.4	32.6	29.2	40.3	41.0		61.6	33.5
20-24	34.3	27.1	24.0	23.4	26.4	25.9	28.9	31.0	41.3	67.3	26.4
25-29	30.2		24.9	24.4	25.9	28.5	32.1	34.0	30.3	79.7	26.0
30-34	39.4		31.5	28.8	29.8	32.1	33.1	36.0	39.2	95.0	30.8
35-39	60.0		46.2	37.2	37.5	41.2	41.8	42.4	45.7	105.4	40.4
40 and over		48.4		42.8	49.2	50.0	53.9	57.4	53.6	113.1	52.9
Not stated	60.6	58.2	65.6	60.3	74.2	69.9	79.5	105.6	52.6	115.7	108.7
Total	34.4	28.6	25.1	26.3	31.1	38.0	42.8	45.7	45.0	79.4	31.1

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carried to full term. For the latter reason these births might represent a better index of qualitative fertility than do stillbirths and neonatal deaths.

Reliable information on the incidence of premature birth for the entire country is not available. The following discussion is based on the 1936 (over 82,000) births in New York State exclusive of New York City. These births were tabulated according to the physician's statement on the birth certificate as to whether the birth was full term or premature. Such a classification is not altogether satisfactory. It suffers from the fact that it is not based on an objective criterion of prematurity. In addition it does not afford a sufficiently graded classification. Furthermore, in order that the rates should be more stable, a much larger number of births than the 82,000 available is desired. The following notes are presented therefore merely as indications which must be substantiated by further study.

Table 7 presents the incidence of premature births per 1,000 total births (including stillbirths) by age of parents in broad age groups.

TABLE 7

Incidence of premature births per 1000 total births (including stillbirths) by age of parents. New York State (exclusive of New York City) 1936

AGE OF MOTHER	AGE OF FATHER			
	Under 25	25-34	35 and over	Total
Under 25	61.2	48.9	50.2	57.5
25-34	58.2	48.3	48.9	49.8
35 and over	166.6	64.4	69.5	69.7
Total	61.2	48.9	58.7	55.6

The incidence of premature birth by age of mother as well as by age of father followed a similar trend to that of the stillbirth rate with high incidence in the young and old groups and lower incidence in the intermediary group. This pattern is evident for each row and for each column, that is, these differences in incidence by age of one of the parents are independent of the age of the other parent.

There was a distinct difference in the variability of the incidence of prematurity between the two parents. The incidence for the older mothers was considerably higher than that for young mothers, while for fathers a reverse trend was noted; the incidence for old fathers was slightly lower than that of young fathers. Hence, in the case of the variation of the incidence of premature birth with age of parents, the relationship is more pronounced for young than for old fathers and for old than for young mothers. The highest incidence was recorded for the group consisting of the youngest fathers and the oldest mothers.

In addition to incidence it is of interest to consider the mortality of the premature by age of parents. This may be measured by the number of premature stillbirths and neonatal deaths per 1,000 total premature births (late fetal and neonatal mortality of the premature). This rate was very high. Over 53 percent of the prematurely born infants did not live to be one month old. When the premature births were subdivided into the various ages of the parents the numbers in each classification became too small to show reliable differences. However, when they were combined into the broad age groups of under and over 30 the rate increased with the ages of both parents independently, as may be seen from Table 8.

TABLE 8

Late fetal and neonatal mortality rates of premature births per 1000 total premature births, by age of parents. New York State (exclusive of New York City), 1936

AGE OF MOTHER	AGE OF FATHER	
	Under 30	30 and over
Under 30	478.2	542.2
30 and over	569.9	593.7

That the incidence and mortality of premature births are not the only factors which are responsible for the variation of the stillbirth and neonatal mortality rates with age of parents can be seen from Table 9 which presents the late fetal and neonatal mortality rates by age of parents for full term births only.

TABLE 9

Late fetal and neonatal mortality rates, by age of parents. Full term births in New York State (exclusive of New York City), 1936

AGE OF MOTHER	AGE OF FATHER								
	Under 20	20-24	25-29	30-34	35-39	40-44	45-49	50 and over	Total
Under 20	17.0	25.3	26.3	26.4	...	...	50.0*	...	25.1
20-24	14.0	27.2	22.3	25.0	26.6	24.1	33.3*	...	24.4
25-29	...	35.8	25.8	24.3	28.9	37.7	37.7	49.0	26.7
30-34	...	96.8*	32.7	28.5	33.9	28.4	33.9	24.5	31.3
35-39	...	...	89.1	30.4	35.5	42.4	57.6	43.9	40.8
40 and over	...	...	**	32.8*	49.7	61.0	59.9	75.6	61.5
Total	16.2	27.5	24.8	26.1	32.8	40.0	51.6	54.8	29.6

* Based on less than 1000 cases.
** Less than ten births.

The variations of the rates for full term births with age of both parents were considerable. The higher the ages of the parents, the higher was the rate. This increase in the rate was again independent of the correlation between the ages of the two parents.

It may be of interest to note one difference between the rates for full term births and the incidence of prematurity by age of father. The full term births of the young fathers did not show the handicapping observed in the incidence of premature birth or in the stillbirth rates for the entire group.

If these results would be substantiated by further study they would indicate that the high stillbirth rates associated with the young ages of the father are due almost entirely to the high incidence of premature births while the high rates associated with the older ages of father are the result of the high incidence of prematurity as well as the high rates of the full term births.

SUMMARY

Stillbirth rates by age of parents for the five year period 1931 to 1935 in the United States Birth Registration Area are presented. It is shown that there is a marked relation between the stillbirth rate and

the age of each parent. The relationship is found to be independent of the correlation of the ages of the two parents.

The variation of the rates with the age of either parent when the age of the other is kept constant is in the form of a U-shaped curve. The rates are high for young and old parents and low for the intermediary ages. This pattern is present for both boys and girls.

Figures for New York State (exclusive of New York City) are presented which show that the incidence of premature birth by age of parents follows a similar trend to the stillbirth rate. In this case the relationship is more marked for young than for old fathers.

The late fetal and neonatal mortality rates for full term births are also closely related to age of parents. The pattern is similar to that of total stillbirth rates with the exception that in the case of full term births the rates for young fathers are relatively low.

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BODY-BUILD AND DIAGNOSIS OF SCHIZOPHRENIA

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THE problem of constitution in its relation to medical science may be defined as the extent to which gross body type is correlated with immunity and susceptibility to various diseases. I have the greatest confidence in the ultimate productiveness of research in this subject." (Hooton) Defeatist scepticism in medical circles has received the studies of disease by measurements of body build. Some of the queries heard are worth answering.

Is this anatomical approach of use to physicians? Yes, surface and bony anatomy, long thought a need for surgeons only, has for a decade been more and more applied in studies of constitutional disease, which becomes ever increasingly important with the conquest of infectious disease. Anatomy is revivified by applied anthropology.

Is suitable technic available? Yes, in the laboratory of the physical anthropologist. Improvements and extensions are being frequently reported in the anthropological literature. Too often medical men have adopted obsolete methods and then lamented that the results were useless.

Are the resulting values on patients sufficiently different from normals to be distinguished? Yes, (a) if suitable normal controls be traced in the literature or be provided for publication in accessible medical journals. And (b) if the observations on patients be treated not merely by the average but by showing the variability of that average due to chance; thus the interpretation of any difference of that mean from other means is no longer dependent on clinical guess but can be estimated in terms of precise probability. Such an estimate, while based on mathematics, often needs no knowledge of calculus and could well be included in medical searching.

Are series of patients better than suitable single cases strictly studied? How often we see one patient cited as warrant for a far-flung hypothesis,

then another patient is adduced as disproof. Clearly, a series is necessary when one case is not crucial. Generalization from the unique is easier, often necessary for immediate treatment, and best for assessment of a mental or physical process. But in more chronic states analysis of the multiple factors may be advanced less by seriatim study than by studies of series.

Are significant differences, when found, explicable in terms of disease causation? Consider the untold space in good journals filled with numerical values on temperature, pulse, respiration, weight, blood-constituents, and cruder quantitations; how often they are admitted by the author tacitly or explicitly to be (a) "essentially negative"; (b) inexplicable but thought worth record. So with constitutional observations, they are sometimes not demonstrably significant and sometimes not explicable. But, as in other fields of biology, pragmatic record of fact commonly antedates elucidation.

The general topic of build and disease, the literature, and methods of measurement and analysis, can be dispensed with for the present purpose; any worker along these lines can find details in my previous paper.

MATERIAL AND MEASUREMENTS

Subjects. White males between 20 and 80 years in state institutions, the schizophrenics and convicts in Illinois, the manic-depressives in Illinois and California. Excluded were those suffering from physical defects or diseases apt to affect build. The use of the convicts may be questioned: does the social non-adaptability of the convict affect or result from his constitutional type? Is there any common denominator in the non-adaptability of the convict and the schizophrenic? Answers can hardly be given at present, but it is claimed that the convicts afford the most suitable control series published.

Diagnoses. Here it will be demonstrated that there are differences of body-build in schizophrenics both in its several clinical types and in relation to other conditions. Demonstration of such associations between build and diagnosis is not claimed to show causation. To do that, further work will be necessary.

The psychiatrist may object that division into schizophrenic and manic-depressive groups is arbitrary at present; the reply is that initial diagnoses were imperative, and made by the psychiatrists, were free from danger of bias which might easily have ensued if the build student had

undertaken to define also the mental state. The set-up was therefore unbiased, and the resulting differences are therefore validly associated with the initial diagnostic grouping on the whole. In some individual instances, any build association certainly appears absent, but these apparent exceptions, which might be interpreted as defects of build-theory, may alternatively be ascribed to defects of diagnosis, such as those objected to at the beginning of this paragraph. That objection, in short, contributes nothing to the solution of the diagnostic difficulty, whereas the method proposed contributes evidence supporting that of prior advocates of build-mind relationships.

Age. In the prior paper was shown the extent to which adult age changes need to be considered in interpreting build changes. Here those precepts will be followed whenever the number of patients is adequate.

Though the range of age was the same for each of the four clinical types of dementia precox, the average age varied. Beginning with the youngest we have:

	Years	*Number*
Catatonic type	36.3	50
Hebephrenic type	37.5	204
Paranoid type	43.7	42
Simple type	45.4	32
All types	38.9	328

Basal Tables. The original measurements on the patients, and even the frequency distributions will be omitted here owing to their bulk. The reduced data are recorded in four tables of constants, one for each clinical type of schizophrenia. (Tables 1, 2, 3, 4.) The constants for the total series of 328 men can be found in the prior paper.

GROUP COMPARISONS

Comparisons. For each physical trait, average for one group will be contrasted with the average for another. The groups considered are:

Schizophrenics, type vs. type
Schizophrenics vs. convicts
Schizophrenics vs. manic-depressives.

Schizophrenics, type vs. type. Since three of the four types have each 50 or less subjects, they are not split into smaller age-groups, but each type without regard to age is compared successively with the whole

TABLE 1

TABLE OF CONSTANTS

Schizophrenia, Catatonic Age = 36.3 years (20-80) N = 50

Illinois Racial Stocks: All White

Measurements metric and without clothing

MEASUREMENT		MEAN	± PE	SD	± PE	CV	± PE
Weight in k.	W	63.940	.964	10.102	.681	15.800	1.092
Stature in mm.	S	1692.200	5.579	58.482	3.945	3.456	.233
Sitting height	Si	892.800	2.698	28.287	1.908	3.168	.214
Chest Circumf.	C	881.600	5.928	62.143	4.192	7.047	.478
Trans.	T	298.200	2.492	26.123	1.762	8.760	.595
Ant.post.	AP	218.500	1.686	17.671	1.192	8.087	.549
Module	ChM	261.580	1.773	18.590	1.254	7.107	.482
Shoulder Biacromial	BA	377.900	1.837	19.253	1.299	5.095	.345
Pelvis Bicristal	BC	290.600	1.294	13.566	.915	4.668	.316
Head Length	L	192.460	.628	6.579	.444	3.418	.231
Breadth	B	155.700	.549	5.755	.388	3.696	.250
Height	OH	128.460	.524	5.492	.370	4.275	.289
Module	CM	158.960	.361	3.784	.255	2.380	.161
Face Height	MN	125.780	.695	7.286	.491	5.792	.392
Breadth	BZ	141.561	.572	5.940	.405	4.196	.286
Module	FM	134.010	.536	5.563	.379	4.151	.283
Nose Height	NH	56.020	.378	3.967	.268	7.082	.480
Breadth	NB	37.040	.264	2.771	.187	7.481	.507
	W/S	37.800	.616	6.453	.435	17.071	1.185
	Si/S	52.840	.132	1.389	.094	2.629	.177
	C/S	52.240	.432	4.528	.305	8.668	.589
	T/S	17.970	.163	1.712	.115	9.529	.649
	AP/S	12.994	.110	1.158	.078	8.912	.606
	ChM/S	15.500	.119	1.251	.084	8.074	.548
Above-named	BA/S	22.366	.118	1.237	.083	5.532	.374
measurements	BC/S	17.198	.084	.878	.059	5.105	.345
in percent of	L/S	11.386	.045	.467	.031	4.104	.277
Stature	B/S	9.234	.040	.415	.028	4.494	.304
	OH/S	7.622	.038	.396	.027	5.193	.351
	CM/S	9.416	.032	.333	.022	3.537	.239
	MN/S	7.374	.042	.437	.029	5.922	.401
	BZ/S	8.388	.043	.451	.031	5.373	.367
	FM/S	7.931	.037	.385	.026	4.855	.332
	NH/S	3.268	.024	.251	.017	7.679	.521
	NB/S	2.191	.016	.167	.011	7.639	.518
Index Chest	AP/T	72.700	.599	6.277	.423	8.634	.587
Trunkbreadth	BC/BA	76.640	.449	4.705	.317	6.139	.416
Cephalic	B/L	81.080	.403	4.228	.285	5.214	.353
Facial	MN/BZ	89.031	.480	4.978	.339	5.591	.382
Face/Head L	MN/L	65.380	.384	4.024	.271	6.155	.417
Face/Head B	BZ/B	91.020	.337	3.502	.239	3.848	.263
Nasal	NB/NH	66.540	.610	6.394	.431	9.609	.654

TABLE 2

TABLE OF CONSTANTS

Schizophrenia, Hebephrenic Age = 37·5 years (20-80) N = 204

Illinois Racial Stocks: All White

Measurements metric and without clothing

MEASUREMENT		MEAN	± PE	SD	± PE	CV	± PE
Weight in k.	W	61·706	·416	8·819	·294	14·291	·487
Stature in mm.	S	1682·647	3·150	66·704	2·227	3·964	·133
Sitting height	Si	884·877	1·685	35·600	1·192	4·023	·135
Chest Circumf.	C	867·255	2·736	57·945	1·935	6·683	·224
Trans.	T	284·755	1·045	22·128	·739	7·771	·261
Ant.post.	AP	216·975	·907	19·117	·642	8·811	·298
Module	ChM	253·163	·827	17·421	·585	6·881	·232
Shoulder Biacromial	BA	374·892	·944	19·999	·668	5·335	·179
Pelvis Bicristal	BC	290·407	·872	18·472	·617	6·361	·213
Head Length	L	191·127	·359	7·538	·254	3·944	·133
Breadth	B	154·898	·294	6·188	·208	3·995	·135
Height	OH	128·957	·267	5·553	·189	4·306	·147
Module	CM	158·228	·224	4·653	·158	2·941	·100
Face Height	MN	124·850	·359	7·538	·254	6·037	·204
Breadth	BZ	140·290	·282	5·907	·199	4·211	·142
Module	FM	132·700	·264	5·546	·187	4·179	·141
Nose Height	NH	55·600	·196	4·105	·138	7·383	·250
Breadth	NB	36·270	·129	2·712	·091	7·478	·254
Above-named measurements in per cent of Stature	W/S	36.696	.222	4.698	.157	12.803	.434
	Si/S	52.601	.061	1.297	.043	2.466	.083
	C/S	51.598	.171	3.628	.121	7.031	.236
	T/S	17.198	.063	1.337	.045	7.773	.262
	AP/S	12.905	.056	1.188	.040	9.203	.311
	ChM/S	15.050	.052	1.098	.037	7.294	.246
	BA/S	22.293	.058	1.235	.041	5.541	.186
	BC/S	17.271	.046	.973	.032	5.635	.189
	L/S	11.374	.026	.549	.018	4.828	.163
	B/S	9.226	.024	.500	.017	5.417	.183
	OH/S	7.673	.017	.353	.012	4.605	.157
	CM/S	9.420	.019	.394	.013	4.178	.142
	MN/S	7.430	.021	.450	.015	6.059	.205
	BZ/S	8.345	.020	.428	.014	5.131	.173
	FM/S	7.898	.018	.370	.012	4.691	.159
	NH/S	3.263	.013	.270	.009	8.282	.281
	NB/S	2.158	.009	.189	.006	8.764	.298
Index Chest	AP/T	75.213	.302	6.369	.214	8.468	.286
Trunkbreadth	BC/BA	77.225	.248	5.244	.175	6.790	.228
Cephalic	B/L	81.159	.200	4.214	.142	5.192	.175
Facial	MN/BZ	89.120	.254	5.316	.179	5.965	.202
Face/Head L	MN/L	65.455	.205	4.292	.145	6.557	.222
Face/Head B	BZ/B	90.635	.155	3.251	.110	3.598	.121
Nasal	NB/NH	65.560	.322	6.753	.228	10.300	.351

TABLE 3

TABLE OF CONSTANTS

Schizophrenia, Paranoid Age = 43.7 years (20-80) N = 42

Illinois Racial Stocks: All White

Measurements metric and without clothing

MEASUREMENT		MEAN	± PE	SD	± PE	CV	± PE
Weight in k.	W	63.786	1.242	11.935	.878	18.712	1.424
Stature in mm.	S	1669.762	6.517	62.611	4.608	3.750	.276
Sitting height	Si	886.667	3.434	32.998	2.428	3.722	.274
Chest Circumf.	C	893.571	8.414	80.846	5.949	9.048	.671
Trans.	T	297.143	2.333	22.418	1.650	7.544	.558
Ant.post.	AP	223.667	2.332	22.405	1.649	10.017	.745
Module	ChM	264.000	2.222	21.346	1.571	8.086	.599
Shoulder Biacromial	BA	380.333	1.933	18.570	1.367	4.883	.360
Pelvis Bicristal	BC	294.381	2.013	19.341	1.423	6.570	.486
Head Length	L	190.833	.718	6.900	.508	3.615	.266
Breadth	B	154.786	.672	6.452	.475	4.169	.307
Height	OH	129.817	.515	4.891	.364	3.768	.281
Module	CM	158.415	.396	3.755	.280	2.370	.177
Face Height	MN	124.310	.784	7.532	.554	6.059	.448
Breadth	BZ	140.167	.534	5.130	.378	3.660	.270
Module	FM	132.452	.525	5.047	.371	3.811	.281
Nose Height	NH	54.786	.476	4.575	.337	8.351	.619
Breadth	NB	37.071	.319	3.066	.226	8.270	.613
Above-named measurements in percent of Stature	W/S	38.095	.730	7.013	.516	18.409	1.400
	Si/S	53.190	.125	1.205	.089	2.265	.167
	C/S	53.619	.551	5.296	.390	9.877	.734
	T/S	18.069	.146	1.406	.103	7.781	.576
	AP/S	13.421	.156	1.496	.110	11.145	.830
	ChM/S	15.771	.135	1.299	.096	8.238	.610
	BA/S	22.800	.098	.943	.069	4.138	.305
	BC/S	17.607	.111	1.062	.078	6.034	.446
	L/S	11.436	.053	.513	.038	4.490	.331
	B/S	9.317	.060	.573	.042	6.155	.455
	OH/S	7.752	.037	.354	.026	4.571	.341
	CM/S	9.498	.039	.373	.028	3.929	.293
	MN/S	7.460	.051	.491	.036	6.580	.486
	BZ/S	8.398	.044	.419	.031	4.988	.368
	FM/S	7.943	.039	.374	.028	4.704	.347
	NH/S	3.240	.031	.295	.022	9.113	.676
	NB/S	2.231	.022	.216	.016	9.689	.720
Index Chest	AP/T	74.310	.578	5.556	.409	7.477	.553
Trunkbreadth	BC/BA	77.357	.448	4.307	.317	5.568	.411
Cephalic	B/L	81.381	.494	4.751	.350	5.838	.431
Facial	MN/BZ	88.881	.636	6.114	.450	6.879	.509
Face/Head L	MN/L	65.310	.441	4.234	.312	6.483	.479
Face/Head B	BZ/B	90.524	.357	3.431	.252	3.790	.279
Nasal	NB/NH	68.119	.829	7.967	.586	11.696	.872

TABLE 4

TABLE OF CONSTANTS

Schizophrenia, Simple Age = 45.4 years (20-80) N = 32

Illinois Racial Stocks: All White

Measurements metric and without clothing

MEASUREMENT		MEAN ±	PE	SD ±	PE	CV ±	PE
Weight in k.	W	60.625	1.219	10.222	.862	16.861	1.461
Stature in mm.	S	1681.875	9.276	77.799	6.559	4.626	.391
Sitting height	Si	887.500	4.309	36.142	3.047	4.072	.344
Chest Circumf.	C	880.625	7.558	63.391	5.344	7.198	.610
Trans.	T	292.813	3.309	27.753	2.340	9.478	.806
Ant.post.	AP	222.161	2.090	17.250	1.478	7.765	.669
Module	ChM	261.323	2.239	18.483	1.583	7.073	.609
Shoulder Biacromial	BA	370.750	2.027	17.002	1.433	4.586	.387
Pelvis Bicristal	BC	291.063	1.929	16.175	1.364	5.557	.470
Head Length	L	194.565	.765	6.314	.541	3.245	.278
Breadth	B	155.726	.716	5.911	.506	3.796	.326
Height	OH	128.567	.707	5.738	.500	4.463	.389
Module	CM	159.633	.540	4.385	.382	2.747	.239
Face Height	MN	127.790	.991	8.184	.701	6.404	.551
Breadth	BZ	139.597	.682	5.630	.482	4.033	.346
Module	FM	133.919	.651	5.374	.460	4.013	.344
Nose Height	NH	56.677	.510	4.207	.360	7.424	.639
Breadth	NB	36.484	.291	2.404	.206	6.588	.567
Above-named measurements in percent of Stature	W/S	36.000	.643	5.397	.455	14.991	1.292
	Si/S	52.719	.162	1.273	.107	2.414	.204
	C/S	52.469	.434	3.640	.307	6.937	.588
	T/S	17.669	.199	1.667	.141	9.437	.803
	AP/S	13.194	.126	1.038	.089	7.867	.678
	ChM/S	15.577	.130	1.072	.092	6.883	.592
	BA/S	22.056	.141	1.185	.100	5.371	.454
	BC/S	17.344	.105	.882	.074	5.084	.430
	L/S	11.553	.052	.427	.037	3.697	.317
	B/S	9.276	.062	.512	.044	5.517	.474
	OH/S	7.637	.048	.389	.034	5.090	.444
	CM/S	9.487	.046	.376	.033	3.960	.345
	MN/S	7.603	.067	.552	.047	7.262	.625
	BZ/S	8.303	.053	.439	.038	5.285	.454
	FM/S	7.958	.050	.415	.036	5.213	.448
	NH/S	3.306	.032	.262	.022	7.938	.684
	NB/S	2.168	.022	.184	.016	8.499	.733
Index Chest	AP/T	74.306	.721	5.954	.510	8.012	.691
Trunkbreadth	BC/BA	78.688	.547	4.584	.386	5.825	.493
Cephalic	B/L	80.129	.467	3.858	.330	4.815	.413
Facial	MN/BZ	91.855	.829	6.842	.586	7.448	.642
Face/Head L	MN/L	65.613	.534	4.404	.377	6.713	.578
Face/Head B	BZ/B	89.710	.387	3.195	.274	3.561	.305
Nasal	NB/NH	64.952	.825	6.810	.583	10.485	.908

series of 328 schizophrenics. The results can be condensed as follows. The catatonic type shows not one significantly different trait. The simple type is significantly longer in the head. The hebephrenic type is significantly narrower across the chest, both absolutely and relative to stature.

The paranoid type exhibits marked physical deviations from the whole, all toward the so-called pycnic or lateral build. Listing only the traits for which the differences between paranoid mean and total mean exceed 3 PE, we find that transverse chest breadth and chest module (the mean of breadth and depth), both absolutely and relative to stature, is big in the paranoids. Also bi-acromial shoulder-breadth relative to stature and bi-cristal pelvic breadth relative to stature, i.e. the trunk is broad at both top and bottom. Also sitting-height relative to stature, i.e. the trunk is long relatively, or legs short relatively, a condition opposite to the eunuchoid and therefore suggestive of hyper-gonadism. Apart from this suggestion, we cannot explain why these differences should exist.

Schizophrenics vs. convicts. As a parallel to an earlier paper comparing manic-depressives with convicts, comparison is now made between schizophrenics and convicts. The convicts are used as a sample of the same regional and economic strata, in which respects at least they provide a fitter control than army data. The schizophrenics are used without regard to psychiatric type. As basis of reference we take our convict data. Having regard to age, we make 3 sets of comparisons: (a) for all ages together, (b) and (c) for shorter age-periods, as follows:

	Years	*Average years*	*Number*
(a) Schizophrenics	20-80	38.9	328
vs. convicts	20-80	33.9	587
(b) Schizophrenics	20-40	31.3	180
vs. convicts	20-40	28.3	429
(c) Schizophrenics	40-60	46.6	139

All three age-groups yielded similar results; that is, significant differences between schizophrenics and convicts were manifested by one age-group for 5 items, two age-groups for 10 items, and all three groups for 18 items. The sum is 33 significant items out of the total 42 items, i.e. 79 percent. The schizophrenics were smaller than convicts in about half the items, larger in the other half; the particular characteristics are arranged in Table 5.

TABLE 5

Schizophrenics vs. convicts

SCHIZOIDS SMALLER			SCHIZOIDS LARGER		
	Absolute	Relative to stature		Absolute	Relative to stature
Weight	W	W/S	Head breadth	B	B/S
Stature	S	....	Head height	OH	OH/S
Sitting-height	Si	Si/S	Head module	CM	CM/S
Chest circumference	C	C/S	Face height	....	MN/S
Chest transverse...	T	T/S	Face breadth.....	....	BZ/S
Chest anterior-posterior	AP	AP/S	Face module	....	FM/S
Chest module	ChM	ChM/S	.....	....	....
Shoulder breadth...	BA	....	.....	....	....
Pelvic breadth	BC	....	Pelvic breadth	....	BC/S
Nose height.....	NH	NH/S	Nose breadth	....	NB/S
					Indices
			Deep chested.....	....	AP/T
			Feminine trunk breadth ratio.....	....	BC/BA
			Round headed.....	....	B/L
			Broad face/head ...	....	BZ/B
			Broad nose.....	....	NB/NH

It is curious that certain of the schizophrenic differences from convicts are in the same direction as deviations in the manic-depressives previously reported. That is, both psychoses were:

Smaller than convict controls in:		*Larger in:*	
Sitting-height (eunuchoid)	Si, Si/S	Head breadth	B, B/S
Chest-transverse (narrow-chested)	T, T/S	Pelvic breadth (feminine)	BC/S
		Chest index (deep-chested)	AP/T
		Trunk-breadth index (feminine)	BC/BA

Schizophrenics vs. manic-depressives. Instead of convicts, we now take as basis of reference our manic-depressive data. The treatment is identical. Having regard to age, we make three sets of comparisons: (a) all ages pooled, (b) and (c) for the vicennial age-periods, as follows:

	Years	*Average years*	*Number*
(a) Schizophrencis vs.	20-80	38.9	328
manic-depressives	20-80	48.8	105
(b) Schizophrenics vs.	20-40	31.3	180
manic-depressives	20-40	30.5	26
(c) Schizophrenics vs.	40-60	46.6	139
manic-depressives	40-60	51.1	52

Again all three age-sets yielded congruous conclusions. The schizophrenics were smaller than the manic-depressives in 16, larger in 10 items; details in Table 6.

TABLE 6

Schizophrenics vs. manic-depressives

SCHIZOIDS SMALLER	Absolute	Relative	SCHIZOIDS LARGER	Absolute	Relative
Weight	W	W/S			
Stature	S	....			
Chest circumference	C	C/S			
Chest transverse ...	T	T/S	Head height	OH	OH/S
Chest anterior-posterior	AP	AP/S	Head module.....	....	CM/S
Chest module	ChM	ChM/S	Face length.....	MN	MN/S
Shoulder	BA	....	Face module	....	FM/S
Dolichocephalic	L	....			
Long nosed	NH	NH/S			
		Index			*Indices*
Flat chested	....	AP/T	Feminine trunk	....	BC/BA
			Rounder head.....	....	B/L
			Long faced	....	MN/BZ
			Long faced	....	MN/L

The bi-cristal diameter may be specially noticed. In the paper on manic-depressives, the statement was made: "The breadth of the pelvis, not only in millimeters BC but also in proportion to stature BC/S, and further in proportion to the shoulder breadth BC/BA, is to be emphasized, because in the literature so much has been asserted about excessive breadth of pelvis in precisely the contrary group the schizoids." The statement can now be amplified with our new data; using all ages together, and taking 587 convicts as basis to which we refer alternately 328 schizophrenics and 100 manic-depressives, we find the differences and critical ratios (*CR* = difference divided by its probable error) to be as follows:

BC	Schizophrenics larger than convicts by 1.7 mm. with *CR* 2.2 Manic-depressives larger than convicts by 5.2 mm. with *CR* 4.0
BC/S	Schizophrenics larger than convicts by 0.3 per cent with *CR* 7.6 Manic-depressives larger than convicts by 0.4 per cent with *CR* 6.3
BC/BA	Schizophrenics larger than convicts by 1.44 per cent with *CR* 6.2 Manic-depressives larger than convicts by 1.00 per cent with *CR* 3.3

These values are sufficiently striking. Put into words, as against convicts both psychoses showed abnormally broad pelves, with the schizoids the *less* abnormal; that is the schizophrenics showed *smaller* excess in BC and BC/S than did manic-depressives. It may seem strange that in the trunk-breadth ratio BC/BA, the schizophrenics showed *larger* excess over convicts than did the circular psychoses; this paradox is due to the schizophrenics having undeveloped bi-acromial diameters, BA averaging 4.2 mm. *less* than convicts, while the manic-depressives had broad shoulders, BA averaging 2.5 mm. *more* than convicts.

SUMMARY

Body-build in 328 schizophrenics, subdivided into the four psychiatric forms, is documented by tables of means and variabilities. Giving due respect to human variability (so often ignored), the averages show that a number of physical traits differ to a statistically significant extent.

Contrasted with each other, the four psychiatric types of schizophrenia exhibit some distinctive differences in physique. Catatonics are built like schizophrenics as a whole, the simple type diverges only in being dolichocephalic, and hebephrenics only in being narrow across the chest. More marked divergences are visible in the paranoids: bulky

chests, broad shoulders, trunk as a whole broad, relatively short legs; in sum pycnic, perhaps hypergonadal.

Contrasted with convicts found in the same general environment and so assumed as approximations to normal build, the schizophrenics (grouped and compared in age-classes) show plain physical aberrations. They are smaller in about half the traits measured, and larger in half.

Contrasted with the manic-depressive psychosis, again age for age, the schizoids deviate indubitably, being smaller in half the items, larger in the other half.

The shoulder-breadth, pelvic-breadth, and the ratio between these two ends of the trunk, are specially commented on for the two great psychoses as against non-psychotic man.

The rationale for the associations shown between body and mind cannot unfortunately be proven at present. Nevertheless, the measurements as condensed and tabulated are worth putting on record, and also offer some aid in differential diagnosis. According to the diagnoses subject to comparison at a particular time, one must examine a varying assortment of traits. For discriminating schizophrenia from manic-depressive the set will be composed differently from the set selected to separate out say the paranoid from other types of schizophrenia.

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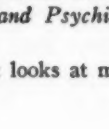

OBSERVATIONS ON THE SIZE AND POSITION OF THE NUTRIENT FORAMEN IN THE RADIUS

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RECENTLY we have been seeking for landmarks in long bones which can be used as points of reference when one is studying growth changes within the cortex. It occurred to us that nutrient foramina might be useful for this purpose since they are not difficult to identify in X-rays which show bone detail. In practice it has been quite easy to locate the foramen in the radius in consecutive X-rays of young children, and it has been a useful point from which to measure the growth of the distal portion of the bone.

The puzzling feature in an X-ray of the foramen is its size which is so much greater than one would anticipate from the adult dried bone. The canal through which the vessels pass usually traverses the cortex obliquely although they enter through a fairly small round foramen. This canal plus the superficial cortical groove through which the vessels approach the foramen of course photographs as a continuous channel. After some study one can identify the proximal border of the foramen proper as a rounded, thickened point. Text-book illustrations are of little help in this determination, although they describe foramen position in some detail. The problem then is to establish a point of reference in the nutrient cortical groove which can be identified in consecutive X-rays.

I took these problems to the late Dr. T. Wingate Todd, as I have taken others repeatedly in the past, and was graciously permitted again to use his excellent collection of human skeletal material to study foramen form and position, and to compare the foramina on young wet specimens with the X-rays of them. The findings substantiated points which we thought we were identifying with some satisfaction in the X-rays of the Fels Research Institute children. The writer is indebted to the late Dr. T.

Wingate Todd and Dr. L. W. Sontag for the use of the bone material and the X-rays included in this study.

THE MATERIAL

The entire collection of skeletons of male and female whites between eighteen and forty-five years of age at death in Hamann Museum, was examined, and fifty pairs of unblemished radii for each sex were selected. All pairs — some ten or twelve — having unilateral or bilateral multiple foramina were discarded. Next, twenty radii from Dr. Todd's collection of young skeletal material between birth and thirteen years of age were chosen in order to compare the dimensions and location of the foramina in the X-ray with the actual specimens. The X-rays of living children are those taken routinely under Dr. Sontag's direction on Fels Research Institute children. The children included were those who had had X-rays at three- or six-month intervals from birth to five years of age. These young foramina were studied to see what developmental features one might expect as the bone enlarges.

MEASUREMENTS MADE

Two measurements of radial size were made — length measured according to Schultz's technique (2) and the "over-all" length through the longitudinal axis of the bone measured with small spreading calipers. A third dimension was studied tentatively — the distance through the mid-longitudinal axis. We intended to see what degree of cupping one might anticipate by subtracting this measurement from the over-all length. The measurements were completed but were not found to be practical since the carpal articulations on the distal articular surface varied so widely.

The first measurement was made to compare our results with those of previous investigators (1). The second measurement was thought to represent most nearly the radial dimension one would get from the X-ray shadow of it.

Two "foramen distances" were tried out — the distance from the proximal end of the radius to the center of the foramen and the distance from the proximal border of the foramen to the distal end of the radius. The second measurement was used. The nutrient vessels are directed toward the elbow when they enter the cortex and, as has been pointed out, the groove rounds off more smoothly at the proximal edge.

ADULT MATERIAL

Radius length[1]

The male radii averages 245 millimeters. The values varied five percent around the mean and were so nearly bilaterally symmetrical that no significant difference was found between right and left sides (Tables 1 and 2). In contrast to this lack of difference, Schultz points out in his article on page 312, that the bones of the upper extremity are more commonly longer on the right in man. Our differences are also less than those quoted by Martin (1). Since their observations have been so much more extensive than those included in this article, the lack of difference found seems to indicate that there was some element of selection in these particular fifty pairs of radii. As far as could be determined the method of measuring was similar to Schultz's method. Our difference for adults resembled the difference found by Wallis (4) for children.

The female radii were thirty millimeters shorter than the male on the average. Again the right and left radii did not differ significantly in length or variability (Tables 1 and 2).

Foramen distance

The foramen was found between a third and a half of the distance down the volar surface of the shaft of the radius. It varied, on the average, about ten to fifteen percent from this distance. The raw data indicates that the general tendency is for the foramen to be more distal than this and therefore nearer the center, for it was two to twelve millimeters nearer the distal end in fifty-nine of the one hundred male radii and seventy-seven of the one hundred female radii which were examined.

The length of the radius determines in part the distance of the foramen from the end (Table 2). In the longer radii it is relatively nearer the proximal end. An interesting point in these radii was that the foramen distances in the left female radii were least related to the actual length of the bone itself and rather significantly different from the male pairs and the female right radii.

There is only a very slight relation between foramen distance in the right and left radii in both sexes (Table 2).

[1] As illustrated by Schultz (2).

TABLE 1

Length of radius, foramen distance, size and location of foramen in adults

	M	PE_M	SD	COEF V	M	PE_M	SD	COEF V
	Right				Left			
Length of radius	239.2	±1.2	12.7	5.3	239.0	±1.1	11.4	4.8
(shadow length)*	211.0	±1.2	12.6	6.0	209.2	±1.2	12.9	6.2
Foramen distance	85.2	±0.9	0.9	10.8	87.2	±1.2	12.5	14.3
Size of foramen**	13.3	±0.6	5.7	41.4	13.8	±0.6	6.0	43.0
	12.9	±0.4	4.6	35.6	11.0	±0.4	4.0	36.4
Location of foramen	19.8V	±1.0	10.5	52.9	18.5V	±0.9	9.2	49.8
	15.8V	±0.7	7.4	46.6	17.2V	±0.6	6.7	38.8
Length of radius	246.3	±1.1	11.8	4.8	235.9	±1.1	11.9	4.8
(central length)	215.8	±1.2	12.1	5.6	214.6	±1.3	13.1	6.1

Length of left diaphysis and foramen distance from birth to 5 years
(measured in mm. from X-rays)

	LENGTH OF DIAPHYSIS (*mm.*)				FORAMEN DISTANCE (*mm.*)			
	M	PE_M	SD	COEF V	M	PE_M	SD	COEF V
1 month	56.4	±0.7	2.7	4.7	37.7	±0.4	2.3	6.1
6 months	66.9	±0.6	3.4	5.1	44.8	±0.5	2.9	6.4
12 months	80.1	±0.5	2.9	3.6	54.2	±0.7	3.9	7.2
24 months	95.6	±1.1	4.5	4.7	64.4	±1.0	3.8	6.0
36 months	109.0	±0.8	4.5	4.1	74.4	±0.7	4.4	5.9
48 months	121.4	±0.7	4.9	4.0	85.1	±0.9	4.5	5.3
60 months	133.0	±1.0	6.0	4.5	92.0	±1.3	7.6	8.3

* Measured in millimeters.

** Measured in 64ths of an inch.

Size of the foramen

The size of the foramen varies too widely for one to put much emphasis on the average. The fineness of the measurement itself (in sixty-fourths of an inch) accounts in part for some of the variability. Although some foramina are perfectly round without much of a groove, the general tendency is for the foramen to be a fairly small opening

TABLE 2

Coefficients of correlation between length of radius, foramen distance, size, and location of foramen in adult skeletons

DIMENSIONS CORRELATED	MALE		FEMALE	
	Right radius	Left radius	Right radius	Left radius
Length of radius and size of foramen...	+.05 ±.10	+.13 ±.09	+.10 ±.09	—.04 ±.10
Length of radius and foramen distance ..	+.44 ±.08	+.41 ±.08	+.51 ±.07	+.25 ±.09
Length of radius and location of foramen	—.21 ±.09	+.02 ±.10	+.14 ±.09	+.09 ±.10
Size of foramen and foramen distance ..	+.17 ±.09	+.45 ±.08	+.18 ±.09	+.45 ±.08
Size of foramen and location of foramen	—.02 ±.10	+.09 ±.10	+.18 ±.09	—.05 ±.10
Foramen distance and location of foramen	—.47 ±.07	—.31 ±.09	+.54 ±.07	—.07 ±.10

Correlations between right and left radii

	MALE	FEMALE
Length of radius....	+.95 ±.01	+.96 ±.01
Size of foramen.....	+.10 ±.09	+.24 ±.09
Location of foramen	+.30 ±.09	+.43 ±.08
Foramen distance....	+.35 ±.08	+.29 ±.09

Correlations between length of radius and foramen distance from birth to five years of age

1 month	+.74	24 months	+.34
6 months	+.55	35 months	+.62
12 months	+.67	48 months	+.41
	60 months	+.60	

through the cortex approached distally by a shallow groove. The groove and opening are included in the measurement of size since this is what one probably sees in the X-ray (Table 3).

The foramen in the female radius tended to be significantly less variable than the male. The correlations (Table 2) between size and radial length do not suggest that the groove is shorter in a short radius—its size is quite independent of radial size in both sexes.

Location of the foramen

Location was expressed as the distance between the proximal border of the foramen proper and the interosseous crest. A record was also made as to whether the foramen was volar or dorsal to the crest, or on it.

Again some of the variation can be attributed to an attempt at over-refined measurement. The foramen was on the crest or dorsal to it in less than five percent of the two hundred bones, although the illustration in Spalteholz (page 113) shows it to be near the crest on the dorsal aspect of the bone. It was nearer the mid-axis of the radius than this particular illustration shows in over ninety percent of the bones examined.

There was neither a tendency toward bilateral symmetry nor a sex difference in the location of the foramen with respect to the interosseous crest.

The observer was at a loss to explain the difference in the relationship between the location of the foramen and its distance from the distal end of the bone in the right and left female radii. As stated before, the left radius tended to differ significantly from the right in several ways, and in the relationship just cited, the difference was clearly significant. The raw data suggests that the difference is due to the greater variation in the location of the foramen in the right radius. This is in accord with Schultz's statement that the extremities in the female differ more in symmetry and size than the male.

THE INFANT SKELETAL MATERIAL

The comparisons made between the size, location, and foramen distance in the radius and the X-rays of them which were made on the wet specimens are given in Table 3. The X-rayed radius was always measured first and no reference was made to that figure when the corresponding measurement was made on the skeleton.

The findings confirmed two preliminary observations made from Fels Institute X-rays, namely that the supra-periosteal dimension differs

from the X-rayed dimension because we are seeing the whole cortical channel.

It is almost impossible to locate the interosseous crest in the X-rays of young children. Apparently the crest was the inner border in these

TABLE 3

Comparison between the location and size of the nutrient foramen in the radius and the foramen distance in the X-ray and on the dissected bone

SEX OF CHILD	AGE OF CHILD			SIZE (64ths. inch)		LOCATION (64ths. inch)		DISTANCE (mm.)	
	Yr.	Mo.	Da.	X-ray	Bone	X-ray	Bone	X-ray	Bone
♀ W rt.	0	6	8	4	2	9	9V*	43.0	42.0
♂ W lft.	0	10	..	7	7	4	5V	41.0	35.0
♀ N rt.	3	..	..	13	13	?	14V	...	...
♂ N rt.	12	..	..	9	9	6	4V	84.5	78.0
♂ N rt.	1	1	20	7	6	3	4V	58.5	57.0
lft.	..	..	..	6	5	6	8V	59.0	57.5
♂ N rt.	1	3	11	5	5	6	7V	60.5	60.5
lft.	..	..	..	8	6	6	5V	61.0	61.0
♂ N rt.	0	0	17	4	3	2	2V	32.5	32.0
lft.	..	..	..	4	4	4	2V	31.0	31.0
♂ W rt.	0	1	0	6	5	2	2V	...	31.0
♀ W lft.	0	8	..	8	6	2	2V	39.5	37.5
♂ W lft.	0	8	..	7	7	6	1V	41.0	38.5
♀ W lft.	0	8	..	5	5	6	5V	...	42.0
♀ W lft.	0	8	..	5	5	8	8V	...	36.5
rt.	..	..	..	5	4	0	9V	...	32.5
lft.	..	..	..	..	4	8	8V	...	30.0
rt.	..	..	..	3	1	On the crest		...	31.5
lft.	..	..	..	3	2	On the crest		...	37.5
rt.	..	..	..	6	5	..	3	29.0	29.0

* V = on the volar surface of the bone.

X-rays and the similarity in measurements of distance from the crest were thus fortuitously got on the green specimen and the X-ray.

The results are similar enough to suggest that with practice the foramen can be observed fairly reliably in the X-ray. The measure-

ment of foramen distance was omitted either because the total length was not X-rayed or the diaphysis was so frayed that precise measurement was impossible.

The foramen as seen in children's X-rays

In practice it was difficult to identify the foramen in children's X-rays in from five to ten percent of the Fels Institute series. The angle from which the X-ray is taken is particularly important when the foramen is near the interosseous crest, and as was pointed out before, it was found on the crest in about five percent of the Hamann Museum adult radii. If the hand is supinated and the elbow is flexed a little the foramen can be located quite readily in X-rays taken for bone detail.

The length of the diaphysis as one sees it in the X-ray and the length of the segment distal to the foramen do not correlate closely from birth to five years of age (Table 2). It was particularly interesting that the relationships between these two dimensions at all these age levels are similar to that seen in adult bones after the epiphysis and diaphysis are united. The correlations for the growing bone were calculated from measurements made on consecutive X-rays of the same sixteen children at every age level.

The increments of growth in the diaphysis and the increases in foramen distance shows that the total increase in the diaphysis is uniform from one to five years of age. The foramen distance decreased in increment of growth between four and five years of age in this group of children. Changes in relationships between the rate of increase in diaphyseal length and foramen distance, therefore, occured just before the first mineral deposits were made in the distal and proximal epiphyseal cartilages respectively. This was seen both in the dimensions given in Table 1 and in the ratios of foramen distance to diaphyseal length which were calculated for forty-one boys. The averages of their ratios at 1, 3, 6, 9, 12, 18, 24, 30, 36, 42, and 54 months were .66, .66, .66, .68, .69, .68, .68, .69, .69, .70, .70 respectively. The finding suggests that the proximal border of the foramen may be a useful landmark for studying changes in growth in the two ends of the bone. Scarring at the distal end of the radius is a point of considerable interest and change in bone pattern coincident with change in rate of growth is of equal interest. It is difficult to measure changes in the trabeculae from roentgenograms, but the X-ray is the only means whereby changes can be studied on the living. For this reason it

seemed of practical value to record these relationships of the foramen, since it is a landmark within the cortex itself. Further proof is needed before one could conclude whether it is a useful landmark for studying differences in growth in the proximal and distal of the bone.

Individual differences in foramen size, shape and location were seen as clearly before the children were two years old as one sees them in a collection of adult radii.

SUMMARY

One hundred pairs of unblemished radii—fifty male white and fifty female white—selected from the collection in Hamann Museum were examined to study the size and location of the nutrient foramen in the radius.

Twenty wet specimens of young bones in the same collection were selected to compare the size and location of the foramen in the X-ray and the green bone.

Three hundred and sixty-three X-rays of 41 boys who had had a series of examinations at three or six month intervals from birth to five years of age at the Samuel S. Fels Research Institute were measured to see what the ratio of the distance of the foramen from the distal end of the diaphysis to the total length of the diaphysis as seen in the X-ray was.

Sixteen of the Fels Institute children had had roentgenograms at every examination made from one month to sixty months inclusive. Means and variations of the diaphyseal shadow and the foramen distance were calculated from their X-rays.

The results showed:

(1) The adult male radius is about thirty millimeters longer than the female. There is no significant difference in the length of the right and left radius for either sex.

(2) The size and location of the nutrient foramen differs in the right and left radius. In relatively longer bones the foramen tends to be slightly nearer the proximal end of the bone.

(3) In the majority of the radii, the foramen was on the volar surface of the bone between the center of the radius and the tuberosity of the biceps, and ten to twenty millimeters from the interosseous crest. In about five percent of the bones it was found on the crest itself. It was seldom seen on the dorsal surface.

(4) The foramen can be identified quite readily in ninety percent or more of the X-rays which are taken for bone detail. Individual differences in form and position can be distinguished before two years of age.

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RELATIVE GROWTH OF THE LIMB BONES IN THE ANTHROPOID APES

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INTRODUCTION

THE limb proportions in the primates, because of their systematic and phylogenetic significance, have received considerable attention at the hands of physical anthropologists. The method of analysis employed in these investigations has been primarily that of computing size indices, or ratios of the size of one part to that of another, and comparing them in adults of different species or in different developmental stages of a given species. The indices commonly used are the brachial index

$$\left(\frac{\text{radius length}}{\text{humerus length}} \times 100\right),$$

the crural index $\left(\frac{\text{tibia length}}{\text{femur length}} \times 100\right)$, and the intermembral index $\left(\frac{\text{humerus} + \text{radius}}{\text{femur} + \text{tibia}} \times 100\right)$.

In many other types of organisms, it has been shown that the relative growth of the parts conforms in a large number of cases to the power function

$$y = bx^a$$

in which x and y are the sizes of two parts, and b and a are constants (see Huxley, 1932). This expression, known as the law of allometry (Huxley and Teissier, 1936), may be written in the form

$$\log y = \log b + a \log x,$$

from which it can be seen that if the data conform to the equation, we obtain by plotting log y against log x a straight line with slope a and

y-intercept log b. The constant a is the equilibrium constant, or the ratio of the percentage growth-rates of the two parts, while b is the initial growth-index, or the value of y when $x = 1$.

Since the above approach permits a more precise and more fruitful analysis than is possible by the comparison of indices alone, it is of interest to examine the applicability of the law of allometry to the relative growth of the limb segments in the primates. An effort in this direction has already been made by Davenport (1934), who applied it to the relative growth of the distal and proximal arm segments in the gibbon, chimpanzee, gorilla, and man. He states that his data do not conform to the equation, but gives no further details. The present investigation deals with its application to the postnatal relative growth of the limb bones in various anthropoid apes of the families Hylobatidae and Pongiidae.

MATERIAL AND METHODS

The investigation is based on the extensive data published by Schultz (1930, 1933), which include measurements of humerus, radius, femur, and tibia length in 48 gibbons (*Hylobates* spp.), 18 siamangs (*Symphalangus syndactylus*), 80 orang-utans (*Pongo pygmaeus*), 36 chimpanzees (*Pan* sp. ?), and 59 gorillas (*Gorilla gorilla*). Measurements are given also for a few specimens of *G. graueri* and *G. beringei,* but these were not used. Schultz's tables contain absolute measurements of only the humerus; the remaining ones were computed from the indices given for each individual.

The data for the orang-utan, chimpanzee, and gorilla were grouped into convenient size classes, the mean values of which were used in plotting the curves presented below. In the Hylobatidae, where measurements are given for several species, each represented by only a small number of specimens, mean values were computed for juveniles and adults of each species. The treatment of these will be described more fully in the next section. In all cases, unfortunately, the adult specimens far outnumber the juvenile, so that the points on the lower portions of the curves represent a much smaller number of individuals than those on the higher portions.

Since in addition many of the juvenile specimens are of unknown sex, it was found unfeasible to treat the sexes separately. Preliminary plots of points for all the individuals, however, indicated no appreciable differences in relative growth between males and females; hence it was

regarded as justifiable to lump them together. Although, according to Schultz (1937), there are significant sexual differences in some of the adult indices, these are not necessarily a consequence of differences in relative growth, as will be shown below.

The following relationships were investigated: radius length / humerus length, tibia length / femur length, and leg length / arm length. The lengths of the leg and arm were taken as the sum of the lengths of the femur and tibia and of the humerus and radius respectively. Values of b and a were calculated by the regression method of least squares (Feldstein and Hersh, 1935). This method, which yields a curve fitted to the logarithms rather than to the arithmetic values, was chosen because it permits the calculation of standard errors of log b and a.

RESULTS

Hylobatidae

The data include measurements on both juvenile and adult specimens of *H. lar, H. pileatus, H. cinereus, H. agilis,* and *S. syndactylus,* and on adult specimens of *H. concolor, H. hoolock,* and *H. klossi.* The relative growth curves obtained by plotting the mean values for juveniles and adults of all the species are shown in Figs. 1 and 2. The values of the constants for these curves are given in Table 1.

Fig. 1 shows the curves for the radius / humerus and tibia / femur relations. In each of these cases all the points fall along a single line, indicating that the course of relative growth is essentially the same in all the species of the Hylobatidae concerned. For both relations a is greater than one, although in the light of the standard errors the deviation from unity appears to be significant only in the radius / humerus relation.

For the relative growth of the arm and leg, on the other hand, a single curve is obtained for all the gibbons (Fig. 2, curve a), from which the two points for the siamang deviate markedly. While the line drawn through these points (curve b) represents only a rough approximation to the true relative growth curve, it is nevertheless evident that there are two distinct, roughly parallel curves. The values of a are both considerably less than unity, and do not appear to be significantly different from one another. There thus exists a dissimilarity in the leg / arm relations of the gibbons and siamang which lies primarily in a difference in the value of b.

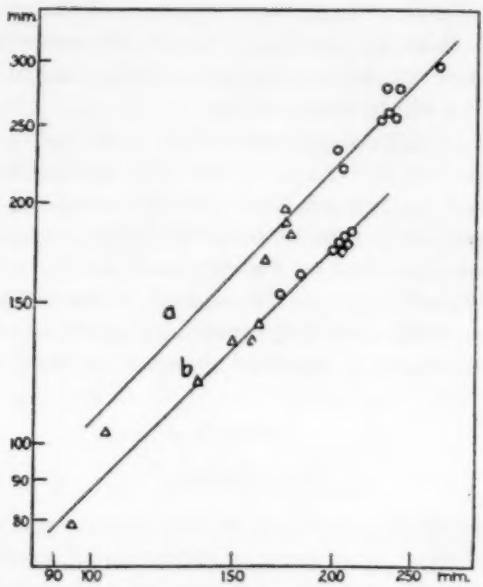

FIG. 1. DOUBLE LOGARITHMIC PLOT OF (a) RADIUS LENGTH AGAINST HUMERUS LENGTH AND (b) TIBIA LENGTH AGAINST FEMUR LENGTH IN THE HYLOBATIDAE
Juveniles are represented by triangles and adults by circles.

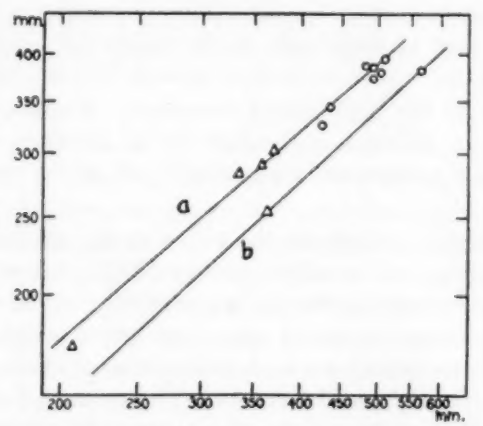

FIG. 2. DOUBLE LOGARITHMIC PLOT OF LEG LENGTH AGAINST ARM LENGTH IN (a) THE GIBBONS (*Hylobates spp.*) AND (b) THE SIAMANG (*Symphalangus syndactylus*)
Juveniles are represented by triangles and adults by circles.

These results are essentially in agreement with those of Schultz (1933), who found that the genus *Symphalangus* is sharply distinguished from *Hylobates* by its markedly greater intermembral index. The present results show in addition that this distinguishing feature is primarily a consequence of a difference in the relative lengths of leg and

TABLE 1

Values of b, log b, and a for the limb relations in the anthropoid apes, with the standard errors of log b and a.

SPECIES	RADIUS/HUMERUS		
	b	log *b*	*a*
Hylobates spp.	0.818	—0.087±0.052	1.0573±0.0222
Symphalangus syndactylus	0.818	—0.087±0.052	1.0573±0.0222
Pongo pygmaeus	0.806	—0.094±0.014	1.0380±0.0057
Pan sp.?	0.950	—0.022±0.023	0.9952±0.0112
Gorilla gorilla	0.925	—0.034±0.023	0.9781±0.0099
	TIBIA/FEMUR		
	b	log *b*	*a*
Hylobates spp.	0.830	—0.081±0.037	1.0104±0.0165
Symphalangus syndactylus	0.830	—0.081±0.037	1.0104±0.0165
Pongo pygmaeus	0.967	—0.014±0.022	0.9905±0.0085
Pan sp.?	0.758	—0.120±0.018	1.0174±0.0092
Gorilla gorilla	1.030	0.013±0.015	0.9574±0.0065
	LEG/ARM		
	b	log *b*	*a*
Hylobates spp.	1.821	0.261±0.037	0.8626±0.0202
Symphalangus syndactylus	1.133	0.054	0.918
Pongo pygmaeus	0.651	—0.182±0.016	1.0086±0.0061
Pan sp.?	0.887	—0.052±0.031	1.0070±0.0114
Gorilla gorilla	0.632	—0.199±0.019	1.0459±0.0049

arm at the time of birth in the two genera, rather than of a difference in their relative growth. It is interesting to note also that *H. klossi*, which Schultz, partly on the basis of limb proportions, assigns to a new subgenus (*Brachytanites*) of *Hylobates* rather than to the genus *Symphalangus*, falls on the same curve as the gibbons in all cases.

Schultz found also that the intermembral index in the adults of different species of gibbons is much more variable than the brachial or crural indices. This is readily explained by the fact that the value of a for the leg / arm relation deviates much more from unity than those for the others, as a consequence of which the intermembral index changes with variations in adult body size to a much greater degree than either of the remaining indices.

More specifically, the intermembral index should be expected to increase in magnitude with increasing femur length. Although the observed adult indices exhibit roughly such a trend, there are nevertheless one or two rather wide departures. The question arises whether these are simply chance fluctuations or whether, on the other hand, the relative growth curves of the various species are not all identical but differ significantly from one another, the curves presented here being merely averages. To obtain an answer to this question, it would be necessary to determine the relative growth constants for each species, a task for which the available data are unfortunately inadequate.

Pongiidae

The relative growth curves for the orang-utan, chimpanzee, and gorilla are shown in Figs. 3-7. In general, the data conform to the equation rather well. The greatest deviations occur in the chimpanzee, where the number of specimens is smallest, and where, because of taxonomic difficulties, no effort has been made to separate the species. Here again it is possible that specific differences in relative growth exist which cannot be ascertained from the available data.

The values of a, given in Table 1, are all in the neighborhood of unity, although in some instances they differ significantly from it. The most outstanding feature is the absence of the pronounced allometry which characterizes the relative growth of the leg and arm in the Hylobatidae.

For the radius / humerus relation, the values of the constants are approximately equal in the Hylobatidae and the orang-utan and in the chimpanzee and gorilla, while the two pairs differ significantly from one another. It may be noted that in the series in Table 1 the values of a decrease progressively from the Hylobatidae to the gorilla. According to Schultz (1930, 1937), the brachial indices of the adults form a similar decreasing series, which indicates that the variations in adult proportions are correlated with variations in a rather than with those in b. Schultz

(1930) found also that the brachial index increases with age in all the higher primates with the apparent exception of the lowland gorilla (*G. gorilla*). This is in agreement with the present results, except that in the chimpanzee the increase appears to be of doubtful significance.

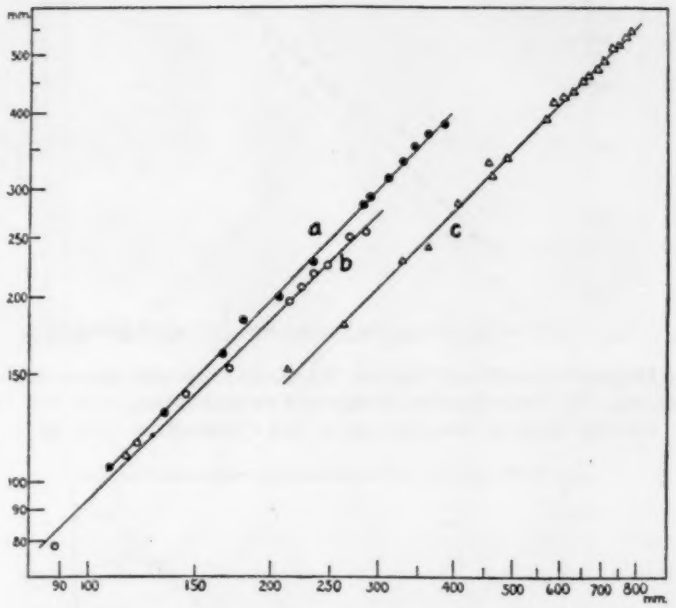

FIG. 3. DOUBLE LOGARITHMIC PLOT OF (a) RADIUS LENGTH AGAINST HUMERUS LENGTH, (b) TIBIA LENGTH AGAINST FEMUR LENGTH AND (c) LEG LENGTH AGAINST ARM LENGTH IN THE ORANG-UTAN (*Pongo pygmaeus*)

For the tibia / femur and leg / arm relations, the orang-utan and chimpanzee have similar values of a but differ appreciably in the value of b. The gorilla has the lowest a and highest b for the first of these relations, and the highest a and lowest b for the second. According to Schultz (1937), the crural index in adults of different species is more uniform than the brachial or intermembral indices. Correspondingly, we find that the value of a for the tibia / femur relation exhibits the smallest range of variation, which again indicates a correlation between adult proportions and a.

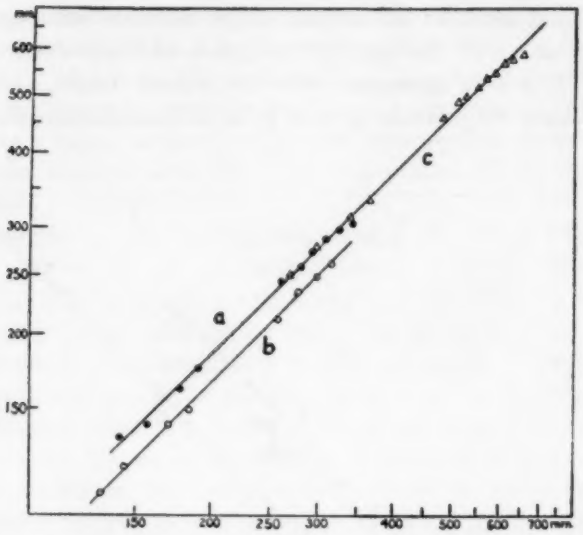

FIG. 4. DOUBLE LOGARITHMIC PLOT OF (a) RADIUS LENGTH AGAINST HUMERUS LENGTH, (b) TIBIA LENGTH AGAINST FEMUR LENGTH, AND (c) LEG LENGTH AGAINST ARM LENGTH IN THE CHIMPANZEE (*Pan* sp.?)

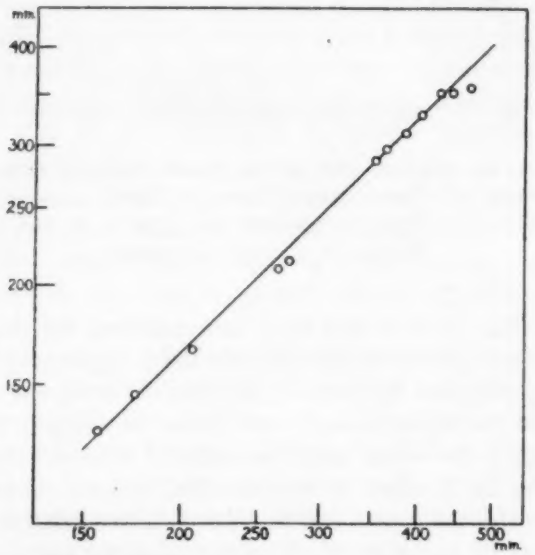

FIG. 5. DOUBLE LOGARITHMIC PLOT OF RADIUS LENGTH AGAINST HUMERUS LENGTH IN THE GORILLA (*Gorilla gorilla*)

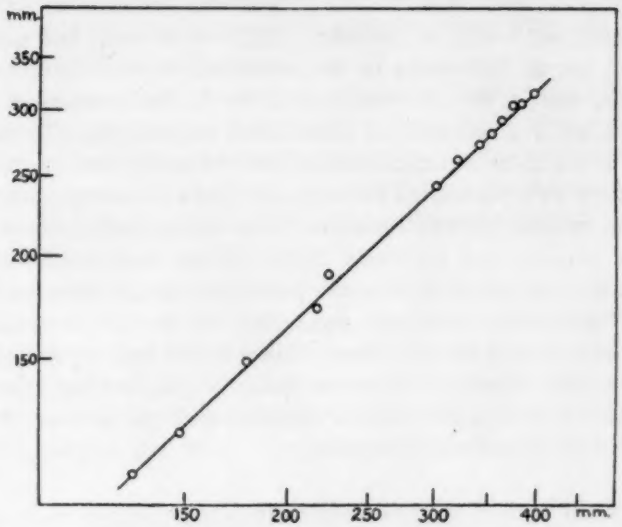

FIG. 6. DOUBLE LOGARITHMIC PLOT OF TIBIA LENGTH AGAINST FEMUR LENGTH IN THE GORILLA (*Gorilla gorilla*)

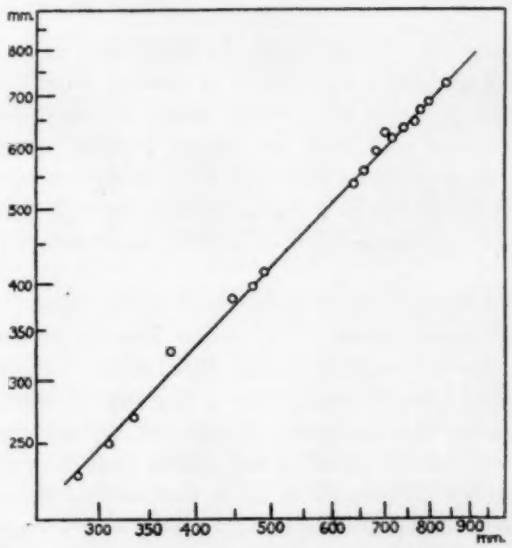

FIG. 7. DOUBLE LOGARITHMIC PLOT OF LEG LENGTH AGAINST ARM LENGTH IN THE GORILLA (*Gorilla gorilla*)

Although in most instances the proportions are alike in adult males and females, the results of Schultz (1937) show small but statistically significant sexual differences in the intermembral and crural indices of the gorilla, and in the intermembral index of the orang-utan. These differences are 1.3, 0.9, and 2.1 index units respectively. To determine whether or not these represent sexual differences in relative growth, the same indices were calculated for each sex from Schultz's data with the aid of the relative growth equation. The corresponding sexual differences are 1.0, 0.7, and 0.2 index units. In the first two instances the observed and calculated values are practically equal, showing that the observed differences are fully accounted for by the dissimilarity in absolute body size in the two sexes. Only in the intermembral index of the orang-utan, where the observed value is considerably greater than the calculated one, is there any indication that the course of relative growth differs in males and females.

DISCUSSION

The evidence presented in the preceding section demonstrates clearly the applicability, at least as a first approximation, of the law of allometry to the data under consideration, and its value as an anthropometric technique.

The constants b and a, which may be interpreted as genetic constants (i.e. descriptive of genetic differences in relative growth in the various species), provide a simple and precise means of associating differences in adult proportions with those in relative growth. It is evident that diversity in adult proportions may arise (a) through variation in absolute body size with no change in b and a, or (b) through changes in either or both of these constants, with or without accompanying variation in body size.

The first of these cases is exemplified by the sexual differences in the gorilla mentioned above. Of special interest in this connection, however, are the relationships in the Hylobatidae. Here, as we have seen, the relative growth curves for a number of species apparently coincide, indicating that the species in question are essentially alike with respect to genetic factors affecting the relative growth of the limb bones, and that whatever differences in adult proportions exist are due primarily to genetic differences in absolute body size. These curves thus not only describe the ontogenetic relative growth in each species, but are at the same time group curves, representing the variation in propor-

tions which accompanies mutations affecting only adult body size in the evolution of the particular group of species. Hence they may be termed curves of evolutionary allometry.

It still remains to be determined, of course, whether or not the ontogenetic curves are actually the same in all the species concerned. However, even if significant differences should be found to exist, they would be relatively small (as compared, for example, to the difference between curves a and b in Fig. 2), and the argument presented in the foregoing paragraph would still be valid in the main.

This type of phenomenon, in which variations in proportions arising within a group of related types of organisms depend primarily on evolutionary changes in absolute body size, appears to be of rather frequent occurrence. Huxley (1932, pp. 212-224) gives a number of examples, and discusses its consequences at some length. More recently, this phenomenon has been rather intensively investigated in certain groups.

The most thoroughgoing of these studies is that of Hersh (1934), who has shown that for certain skull proportions in the titanotheres, the mean values for adults of species comprising a single genus fall on a straight line when plotted logarithmically, and that the lines for different genera are distinct. Hersh suggests that these relationships may be most simply explained as resulting from the coincidence of the ontogenetic relative growth curves in the species of each genus. As evidence supporting this interpretation, he cites the observation of Robb (1929) that the ontogenetic b and a for the relation between pituitary gland weight and cleaned body weight are the same in several varieties of rabbits differing in adult body size. The present results also tend to confirm the validity of Hersh's hypothesis, and still further confirmation is provided by the results of a more recent investigation by Robb (1935a, 1935b), who found that the group curve which he obtained for the muzzle length / total skull length relation in adult fossil and modern horses coincides with the ontogenetic curve for the modern horse.

This hypothesis has been criticized by Hamai (1938), who investigated the relations between breadth, length, and height in certain genera of snails. Although he obtained for the different genera group curves essentially similar to those of Hersh for the titanotheres, he maintains that they are to be regarded purely as average results, and further that they are not to be expressed in terms of ontogenetic growth relations. These conclusions are based on the fact that when the measurements for

individual adult specimens are plotted, the resulting curves for the various species differ in b and a. Also, since these curves involve only adults, they represent, according to Hamai, merely the "direction of variation" and not ontogenetic relative growth.

The validity of these conclusions, even with respect to Hamai's own results, is clearly open to question. With one exception, the differences in b and a in the series of values given by Hamai for the various species fall well below the limit of statistical significance, while in the exceptional case the maximum difference in the particular series lies just at the limit of significance.* Consequently it is not certain that there is any real diversity in the relationships in question. At the same time, the present results as well as those of Robb show that at least in some cases the interpretation of group curves in terms of ontogenetic processes is justifiable. Even in Hamai's investigation the possibility of such an interpretation is by no means ruled out, since it may well be that the constants characterizing the relations in adults of any of the species are the same as those of the corresponding ontogenetic relative growth curves.

Among the genera of the Pongiidae the dissimilarity of adult limb proportions appears to be due primarily to variation in b and a. There are some indications that among the species of any one genus these constants are alike, but the available data are too meager to permit the establishment of this point. It may be pointed out, however, that if this should be established, it would mean that the present situation conforms in the main to the first two tentative rules proposed by Hersh (1934) for the titanotheres, namely that b and a are constant within a genus, and that they vary in different genera.

Hersh found also that among the different genera of titanotheres b is a decreasing exponential function of a, and expressed this as a third tentative rule. A similar type of relationship was obtained by Hamai (1938) for the genera of snails which he investigated. In the present case, the constants for the radius / humerus and leg / arm relations conform to the equation proposed by Hersh, while those for the tibia / femur relation do not, although in all instances an inverse relationship exists. The significance of the exponential relationship as well as the

* The criterion employed here is that for significance of the difference between the largest and smallest of a series of means. For an exposition of this criterion, see Tippett (1931, pp. 53-54).

possible reasons for discrepancies of this type have been dealt with elsewhere by the author (Lumer, 1939), and need not be discussed here.

Huxley (1932) has pointed out that in the evolution of a group, a progressive increase or decrease in body size with no change in b or a results in an orthogenetic trend, and Hersh (1934) has remarked further that in such a series ontogeny strictly recapitulates phylogeny. It is evident, however, that in general no inference can be drawn solely from ontogenetic changes in certain proportions in a particular species regarding the character of those proportions in its ancestors.

Nevertheless, Davenport (1935) argues, apparently on the assumption of the universal validity of the recapitulation concept, that an ontogenetically decreasing index implies an ancestral form with a relatively higher index, and vice versa. For example, he concludes from the fact that the brachial index in the gorilla decreases with age that its ancestor had a relatively shorter humerus. This argument is clearly invalid, for the evolution of the arm in the gorilla may well have involved mutations affecting the course of relative growth. Even if such mutations were not involved, it would still be necessary to know whether the arm of the adult ancestral form was longer or shorter than that of the adult modern gorilla before any such inference could be drawn.

In conclusion, it may be remarked that the present study is largely of a preliminary character, and may profitably be repeated with more ample data. It may also be extended to include the fetal stages, as well as other proportions and other types of primates, particularly the macaque and man. Unfortunately, such an investigation in man is largely precluded at the present time by the scarcity of suitable infant and juvenile skeletal material. It is hoped, however, that as adequate skeletal material is accumulated, such studies will be undertaken.

SUMMARY

The relative growth of the limb bones in the anthropoid apes conforms to the relative growth function $y = bx^a$. In the Hylobatidae, b and a are the same in all the gibbons for the radius / humerus, tibia / femur, and leg / arm relations. The siamang resembles the gibbons in the first two relations, but differs from them in the third. These results indicate that the evolution of the Hylobatidae has involved chiefly mutations affecting adult body size but not the relative growth of the limb segments.

The three genera of the Pongiidae differ for the most part in b and a. Sexual differences in adult proportions, however, are with one exception due entirely to differences in adult body size, and not to differences in relative growth. For the radius / humerus and leg / arm relations, b is a decreasing exponential function of a. The constants for the tibia / femur relation, on the other hand, do not conform to this function, although they are inversely related.

These results are in general in agreement with those of previous investigators.

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PERSONAL CONTACT AS A FACTOR IN THE TRANSMISSION OF STUTTERING

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SOME speech pathologists in the past have been wary of placing too much emphasis on the hereditary factor involved in stuttering because the imitative factor has always overshadowed the biological tendency. If there has seemed to be a tendency for stuttering to 'run in families', the fact has been immediately discounted by the knowledge that speech is a learned process, and therefore, in a large degree, imitative.

But today the speech pathologist thinks of the 'stutter-spasm' merely as an outward sign of an inward dysphemic condition. Hence, research is taking count of the underlying mechanism which seems to predispose a person to stuttering, rather than of the outward sign of stuttering.

MATERIAL

In a recent study, the familial tendency and the association factor were investigated. Information concerning the stutterers in the filial, parental, and grandparental generations and concerning the personal contact of propositi with stutterers was secured from the homes of 204 stuttering propositi and 204 non-stuttering propositi. The latter were matched in age and sex with the stuttering propositi. The sex distribution consisted of 163 males and 41 females.

It is true that there is no known way of measuring the association of one person with another, but one can limit the scope of the association with stutterers. *Association* refers to constant contact with other stutterers, either in the home, or with playmates, or with relatives with whom active friendship is maintained. Casual association was not included as important but associations within the home were considered of the utmost importance. Caution was taken to exclude any association which was not an extended one. If a child was known to have played often or for a considerable number of consecutive days with a stutterer, then

that relationship was considered a definite association. If stutterers visited the home of the propositus often or sat on the porch every evening when the propositus was there, that association was also included as one that was constant. If the stutterer visited often in the home of a stuttering grandparent, then again that contact was classified as an association which must be important. There were some instances of controls who had lived next door to a stuttering playmate, had gone to school with him through the grade school and high school. Stutterers who at the time of the study were associating with other stutterers, but who had not had personal contact with another stutterer at the onset of stuttering were not considered in the tabulation of this data inasmuch as this study was concerned with the incidence of stuttering. These difficulties were recognized and carefully considered in the compilation of the statistics. Among the controls, personal contact with stutterers was considered at any period of the lives of the controls.

ANCESTRY OF STUTTERERS

Table 1 indicates the distribution of stutterers in the ancestry of the stuttering propositi and of the control group: that ancestry includes parents, grandparents, and sibs in each generation. Within this nucleus, there are found 210 stuttering family members in the ancestry of the stuttering group, and 37 stuttering family members in the ancestry of the control group; or in other words, 3 per cent of the family members in the parental and grandparental generations of the stuttering group are stutterers, and .5 per cent of the family members in the parental and grandparental generations of the control group are stutterers. Applying the usual formula for the standard error of a percentage,* the critical ratio of the difference between the percentages is shown as 13. Inasmuch as a critical difference of 3 is indicative of virtual certainty, a difference of 13 may be considered significant. As shown statistically then, there is a critical ratio in favor of the percentage of stutterers in the ancestry of the stuttering group as compared with the percentage of stutterers in the ancestry of the control group.

Whenever stuttering was found in the ancestry of the stuttering propositi or in the ancestry of the non-stuttering propositi, it was tabulated as an apparent stuttering strain, provided that strain appeared in

* See Garrett, H. E., *Statistics in Psychology and Education*, pp. 226-228, Longmans, Green and Co., 1937.

TABLE 1

Distribution of stutterers among the family members, including parents and grandparents of the propositi and their sibs, (uncles, aunts, great uncles, great aunts)

THE ANCESTRY	CONTROL GROUP			STUTTERING GROUP			DIFFERENCE BETWEEN
	N	$P=\frac{N}{Total\ N}$	SE_P	N	$P=\frac{N}{Total\ N}$	SE_P	
		(A)			(B)		
Stuttering family members	37	.0055	.0009	210	.031	.0021	(A) & (B) = .0302±.0022
		(C)			(D)		
Non-stuttering family members	6229	.992	.001	6392	.971	.002	(C) & (D) = .021 ±.002
Total family members	6266	1.	....	6602	1.	....	....

more than one generation. In the non-stuttering group, the strain would be apparent only in the parental and grandparental generations. Table 2 shows that 104 stuttering propositi have apparent stuttering strains, but only 4 non-stuttering propositi show apparent stuttering strains through more than one generation.

It may be concluded then that stutterers show a familial tendency, for stuttering occurs more frequently in the ancestry of the stuttering propositi than it does in the ancestry of the non-stuttering propositi.

TABLE 2

Apparent stuttering strains in stuttering and control groups

	STUTTERING STRAINS	NON-STUTTERING STRAINS
Stuttering group of 204 shows	104	100
Control group of 204 shows...	4	200

ASSOCIATIONS OF STUTTERERS

Now the question as to whether this tendency is a biological one or an imitative one arises. At first glance it might seem as if these stuttering propositi were stuttering because of personal contact with stuttering parents, grandparents, aunts and uncles. For this reason an attempt was made to tabulate personal contacts of stutterers and non-stutterers with stutterers.

Table 3 tabulates the associations of stutterers and controls with stutterers.

TABLE 3

Association of stutterers and controls with other stutterers

STUTTERERS	CASES OF ASSOCIATION WITH OTHER STUTTERERS				NO ASSOCIATION WITH OTHER STUTTERERS		DIFFERENCE BETWEEN
	With males	With females	With males & females	Total			
Males—163	41	19	3	63	100		
Females—41	4	8	0	12	29		(A) & (C) = .074 ± .048
Total—204	45	27	3	75	129	(B)	
$P = \frac{N}{Total\ N}$	..	..	.. (A)	.368	.632		(A) & (B) = .264 ± .046
Se_p	..	..	..	.033	.033		
CONTROLS							
Males—163	37	6	4	47	116		
Females—41	7	6	0	13	28		(B) & (D) = .074 ± .048
Total—204	44	12	4	60	144	(D)	
$P = \frac{N}{Total\ N}$	..	..	.. (C)	.294	.706		(C) & (D) = .412 ± .043
Se_p	..	..	..	.031	.031		

Similarities found in the comparisons made in Table 3 may be summarized as follows:

1. Comparison between (A) and (C) shows a similarity rather than a significant difference between the percentage of stutterers who have

had association with other stutterers and the percentage of controls who have had association with stutterers.

2. Comparison between (B) and (D) shows a similarity rather than a significant difference between the percentage of stutterers who have had no association with other stutterers and the percentage of controls who have had no association with stutterers.

Significant differences found in the comparisons made in Table 3 may be summarized as follows:

1. Comparison between (A) and (B) shows a greater percentage of stutterers who have had no association with other stutterers as compared with the percentage of stutterers who have had association with other stutterers. The critical ratio of the difference as shown statistically is 5.4.

2. Comparison between (C) and (D) shows a greater percentage of controls who have had no association with stutterers as compared with the percentage of controls who have had association with stutterers. The critical ratio of the difference is 9.5.

The conclusions which can be drawn from Table 3 are:

1. There is no significant difference shown between the percentage of stutterers and percentage of controls who associated with stutterers; in other words, the 60 controls who associated with stutterers have about an equal chance of learning stuttering habits as the 75 stutterers who have associated with other stutterers, — that is, if it is assumed that stuttering is transmitted through social heredity.

2. There is no significant difference shown between the percentage of stutterers and the percentage of controls who have had no association with stutterers; in other words, there is almost an equal percentage in each group who have had no association with stutterers.

3. A significantly greater percentage of stutterers have had no association with other stutterers as compared with the percentage of stutterers who have had association with other stutterers.

4. A significantly greater percentage of controls have had no association with stutterers as compared with the percentage of controls who have had association with stutterers.

5. It is noticeable that the stuttering group and the control group show the same tendencies when comparisons are made within the group.

There are other observations which may be noted concerning the figures in Table 3. If stuttering is transmitted by social heredity and yet 60 controls did not become stutterers through this method of trans-

mission, it could be fairly assumed that a like number of the 75 stutterers were equally free from this influence in spite of their association, leaving a difference of 15 (1 in 5), who, it will be assumed, have become stutterers because of association. Hence, it can be said that one out of every five stutterers is credited to social heredity; but there is still a large number of stutterers which must be accounted for in some other category of causation.

A similar comparison can be made in Table 1. It was shown in this table that there were 210 stutterers in the ancestry of the parental and grandparental generations of the stuttering propositi; among the controls, in the same generations, there were 37 who stuttered. If one credits to learning or social heredity the same proportion as was found in the preceding demonstration — that is, one in five — there will be approximately 42 who might stutter because of association with other stutterers. But there would remain 168 stutterers compared to 37 in the control group who would have to be accounted for in some other manner.

Or to interpret these same data in another way; there are 210 stutterers in the ancestry of the stutterers and 37 stutterers in the ancestry of the controls. If it is assumed that these 37 stutterers are isolated cases not showing any inheritance, then it may also be assumed that an equal number of such isolated cases might be found in the ancestry of the stutterers. Therefore, if 37 cases are subtracted from the total of 210 cases, there will be left 173 cases. Then assuming that one in every five of these stuttering cases has been caused by social heredity, there will be a remainder of 139 cases whose causation may be assumed to be due to biological heredity.

The data in Table 3 might be analyzed in another manner. It was noted that 75 of 204 stutterers or 37 per cent had associated with other stutterers; that 60 controls or 29 per cent had associated with stutterers. It has also been noted that this difference was so slight as to be insignificant. But if this analysis of figures were to be carried out, it would be observed that there is a difference of 8 per cent between these two groups which might be explained by social transmission. Furthermore, the fact that 129 of 204 stutterers or 63 per cent had no association with other stutterers while 144 of the controls or 71 per cent had no association with stutterers shows again the slight influence of association in the causation of stuttering. Since over half of the stutterers, however, have had no real personal contact with other stutterers, some more

potent factor of transmission must be predicated to explain the greater percentage in the pedigrees of the stutterers than in the pedigrees of the controls. This slight difference can by no means account for differences running all the way from 60 per cent to 140 per cent.

One will also have to account for the large number of brothers and sisters of stutterers in the filial generation who do not stutter even though they are in constant association with their stuttering brothers and sisters. Table 4 indicates that out of 421 sibs in the filial generation, there are 181 non-stuttering brothers and 191 non-stuttering sisters who are in constant association in the home with stuttering brothers and sisters. Personal contact with stutterers outside of the home was not included in this tabulation.

TABLE 4

Association within the home of non-stuttering brothers and sisters with stuttering brothers and sisters in the stuttering group

Tabulations from data show that out of 421 sibs in the filial generation of the stuttering group:

181 non-stuttering brothers were in direct association with stuttering brothers and sisters

191 non-stuttering sisters were in direct association with stuttering brothers and sisters

Another approach to the problem of association was taken by noting the differences in the association factors between the stutterers belonging to pedigrees showing apparent non-stuttering strains and those belonging to pedigrees showing apparent stuttering strains within the stuttering group. In Table 5, personal contacts with stuttering parents and grandparents were tabulated because these associations were considered the closest associations which a stutterer would have in learning speech habits. Forty-six stutterers, or 44.2 per cent of the stutterers belonging to pedigrees with apparent stuttering strains, had definite associations either with stuttering parents or with stuttering grandparents; 58 stutterers, or 55.7 per cent of the stutterers, belonging to pedigrees with apparent stuttering strains, had no personal contact with stuttering parents or stuttering grandparents, because the parents no longer stuttered, and the grandparents who stuttered were never visited or seen.

TABLE 5

Association of stutterers — belonging to pedigrees with apparent stuttering strains — with stuttering parents and stuttering grandparents

	CONTACT GROUP				NO-CONTACT GROUP			
Stuttering propositi belonging to pedigrees with apparent stuttering strains (104)	Those with parents who stutter at present time		Those with non-stuttering parents, but with stuttering grandparents whom they visit		Those with parents who stuttered only as children		Those with non-stuttering parents and with stuttering grandparents whom they never see	
	N	P	N	P	N	P	N	P
	37	.181	9	.044	38	.186	20	.098

TABLE 6

Association of stutterers — belonging to pedigrees with apparent non-stuttering strains — with other stutterers

	CONTACT GROUP		NO-CONTACT GROUP	
Stuttering propositi belonging to pedigrees showing no apparent stuttering strains (100)	Those showing close association with other stutterers (not parents or grandparents)		Those showing no close association with other stutterers	
	N	P	N	P
	29	.29	71	.71

Table 6 shows the data concerning the associations of stutterers belonging to apparent non-stuttering strains with other stutterers. Twenty-nine percent of these stutterers had association with stutterers, and 71 per cent had no association with other stutterers.

Finally there is one more analysis to be made from the data on association. In Table 5, 58 instances are noted in which the stuttering propositi have ancestors (in direct line) who stutter but with whom the propositi have had no personal contact. If it is assumed that in all other instances of stuttering in the line of direct ancestry, the connection between the stuttering of the propositus and that of the ancestor were transmission by some sort of social influence, there would still be 58 cases in which the assumption could not be made, because, though ancestor and propositus both stuttered in each of 58 cases, they did not live in association with each other. The apparent transmission would need some other explanation than social heredity. If one assumed, to be ultra-conservative, that all of these 58 cases are sporadic — accidental or coincidental — with no causal connection between the stuttering of the ancestor and that of the propositus, one is faced with the problem of explaining why, among the pedigrees of the controls, there are not an equal number of sporadic stutterers. Yet among the ancestors of the controls there were only 16 instances as counted against 3½ times that many among the ancestors of the stutterers. This strongly suggests a causal connection between the stuttering of the propositus and that of the ancestor in these 58 instances; or certainly in 42 cases (58-16).

CONCLUSIONS

From these various studies of personal contact, it may be concluded that the association factor in the incidence of stuttering is a slight one. Yet it must be reasonable to believe that there must be some sort of transmission operating to cause stuttering to 'run' in certain pedigrees.

THE GROWTH FORMULA OF BERTALANFFY AND ITS SIMILARITY TO EQUATIONS FOR EXCITATION AND RECOVERY IN THE CENTRAL NERVOUS SYSTEM*

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IN a recent paper in this Journal, Bertalanffy states that a rational mathematical treatment of growth seems at first rather hopeless and critical investigators, conscious of the overwhelming complexity of the problem, are justly skeptical of such attempts. Nevertheless, according to Bertalanffy, it is possible to derive a formula to support the assumption that growth is conditioned by a counteracting of a furthering surface factor and an inhibiting mass factor and to express in mathematical form the relations between the linear dimensions of surface and volume or mass, which is $m^{2/3}$.

"Organic growth is considered as resulting from the counteracting of destruction and construction of building materials. It is assumed that the former is a function of volume, the latter a function of surface. Morphological and physiological arguments in favor of these assumptions are given, and the equations for linear and weight growth following from them are derived."

"In higher vertebrates, the growth curve is subdivided in cycles caused by events leading to changes in total metabolism . . . . These cycles manifest themselves in characteristic changes of growth rates and growth constants. With respect to these cycles, it is possible to calculate the very complicated growth curves of mammals with all detail by means of the growth equations here developed."

In papers recently published, we have described the results of investigations of vision in man, and suggested formulas for visual thresholds, for light adaptation, and for dark adaptation at the fovea after exposure of the eyes to bright light of varying intensity for different periods of time. The details of the methods used and the calculations

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derived from the results of visual tests have been elsewhere described. From the brief summary which is given in what follows, the similarity of the basis for the growth formula of Bertalanffy and of the basis for our equations for vision will be evident.

The visual tests were made with white squares on a black background, and with white squares with inner black squares as objects with internal contrast. The white squares varied from 40 millimeters to 9 millimeters in size (area 1600 square millimeters to 81 square millimeters) and at the distance from which they were viewed were well within foveal vision. For these white squares the product of the cube root of the area and the minimum light intensity required for threshold vision was found to be a constant, i.e.

$$WA^{1/3} \times I' = C.*$$

For all of the test objects, both white squares, and white squares with inner black areas, the equation was

$$WA^{1/3} \times I' - \left\{ I' \times \frac{BA^{1/3}}{WA^{1/3}} \right\} = C$$

* WA — White area of test object (in mm.); BA — Black area of test object; I' — Intensity of light by which test object is illuminated (in foot candles); I'' — Intensity of light used for bright light adaptation; TDA — Time required for dark adaptation (in seconds); C — a constant for each individual under limited experimental conditions; otherwise the equations represent variables.

and the equation and the constant made it possible to calculate the minimum intensity of light required by an individual to see any test object whose area was known (of the large number of objects that were used — white areas and white areas with inner black areas for internal contrast) after the minimum intensity of light required for the vision of one object had been ascertained by actual tests. The equation for light adaptation is:

$$I^{1/3} \times T = C$$

The equation for dark adaptation is:

$$\frac{WA^{1/3} \times I' - \left\{ I' \times \frac{BA^{1/3}}{WA^{1/3}} \right\}}{(I''^{1/3} \times T)^{1/3}} \times TDA^{1/2} = C$$

The equation for dark adaptation is a mathematical expression of cerebral activity for conscious threshold vision as measured by the duration of the refractory period (the time required for dark adaptation). It is an approximation by means of which the time required by an individual — after exposure to a bright light — until threshold vision is regained, can be foretold from one test with one intensity of light adaptation.

If, in the equation for dark adaptation,

$$WA^{1/3} \times I' - \left\{ I' \times \frac{BA^{1/3}}{WA^{1/3}} \right\}$$

is a constant, (i.e. if the test object and the intensity of light by which it is illuminated are kept the same) the equation becomes

$$\frac{TDA^{1/2}}{(I''^{1/3} \times T)^{1/3}} = C \quad \text{or} \quad \frac{TDA}{(I''^{1/3} \times T)^{2/3}} = C.$$

The expression $(I^{1/3} \times T)^{2/3}$ reminds one of the surface energy of a volume usually expressed in physics by the symbol $V^{2/3}$.

The investigations of vision led to the suggestion that in the central nervous system square roots and cube roots may be indicative of surface and volume reactions, and that in order to express volume and surface reactions in linear terms, the cube root of the volume and the square root of the surface must be used, and that there is a relationship between surface and volume, the square root of the surface is proportional to the cube root of the volume or the surface is proportional to $V^{2/3}$.

The growth formula of Bertalanffy is based upon the same relation between volume and surface as our simpler equations and, on account of the added corrections, gives more precise results than ours which are approximations. As already published, we had found that certain formulas for vision were applicable to the growth of some organisms and that there is a power relation between time and the 2/3 power or the 2/9 power of the number of cells produced. Thus:

For an ascidian (Conklin), the age was proportional to the 2/3 power of the number of cleavages,

For a colony of *Bacillus dendroides* (Thornton), the age of the colony was proportional to the 2/3 power of the size of the colony,

For the eggs of *Rana pipiens*, the time of exposure to heat was proportional to the 2/9 power of the number of cells.

For the chicken embryo (Murray) the age was proportional to the 2/9 power of the dry weight of the embryo.*

That the same relationship holds for the growth of the human being, is shown by the following calculations made from the data given by Quetelet, which constitute "Table 10" in Bertalanffy's paper. The data in the first two columns of the table are from Quetelet, the data in the other columns are our calculations according to the formulas

$\text{Age} \div \text{Weight}^{2/3} = C$ for the calculation of age from the weight, and
$\text{Age}^{3/2} \div \text{Weight} = C$ for the calculation of the weight from the age.

As will be seen from the above table, it is possible to predict the variations of weight with age in the male human being from the ages of thirteen to nineteen by means of the simple surface-volume power relationship; thereafter the simple relationship no longer holds, probably because of the change in the growth cycle at the age of nineteen. This surface-volume power relationship for human growth is further evidence of fundamental significance of these two factors in determining vital activity.

In a report already published, the suggestion was made that the effect of physical energy from outside the body upon the peripheral receptors of the nervous system may be based upon a volume and therefore a cube root reaction. In other words, the visual excitatory process, although it may begin as a surface reaction, is predominantly one in which the entire cells are involved. This is indicated by the power relations between area and intensity—

$$A^{1/3} \times I = C$$

and between intensity and time —

$$I^{1/3} \times T = C.$$

We have elsewhere referred to the fact that in both the visual and the olfactory senses (and probably also in the auditory sense), there is a relation between stimulating time and recovery time which can be expressed mathematically as the cube root of the stimulating time is proportional to the square root of the time required for recovery from the effects of stimulation, or

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* The detailed calculations for these facts are given in the Charles K. Mills Memorial Lecture delivered by one of the writers. In that lecture an attempt was made to explain the fact that volume reactions are expressed either in cube roots, i.e. $X^{1/3}$, or cube roots of cube roots, i.e. $(X^{1/3})^{1/3}$ or $X^{1/9}$, and so on.

TABLE 1

Calculations of age and of weight. (Data of Quetelet for males)

AGE (*years*)	WEIGHT (*kg.*)	Weight$^{2/3}$	Age ÷ Weight$^{2/3}$	Calculated age C = 1.26
13	33.1	10.3	1.26	*12.98*
14	37.1	11.1	1.26	*13.99*
15	41.2	12.0	1.25	*15.12*
16	45.4	12.8	1.25	*16.13*
17	49.7	13.5	1.26	*17.01*
18	53.9	14.3	1.26	*18.02*
19	57.6	14.9	1.28	*18.77*
20	59.5	15.3	1.31	19.28
21	61.2	15.5	1.35	19.53
22	62.9	15.8	1.39	19.91
23	64.5	16.0	1.44	20.16

Age (*years*)	Weight (*kg.*)	Age$^{3/2}$	Age$^{3/2}$ ÷ Weight	Calculated weight C = 1.42
13	33.1	47.0	1.42	*33.1*
14	37.1	53.0	1.43	*37.5*
15	41.2	58.0	1.41	*40.8*
16	45.4	64.0	1.41	*45.1*
17	49.7	70.0	1.41	*49.3*
18	53.9	77.0	1.42	*54.2*
19	57.6	83.0	1.44	*58.4*
20	59.5	90.0	1.51	63.5
21	61.2	96.0	1.56	67.6
22	62.9	103.0	1.63	72.5
23	64.5	111.0	1.72	78.2

Stimulating time$^{1/3}$ divided by Recovery time$^{1/2}$ is a constant, or

Stimulating time$^{2/3}$ divided by Recovery time = Constant.

According to Bertalanffy, actual growth is effectuated by the counteracting efforts of destruction and construction of building materials — the former a function of volume and the latter a function of surface. That cerebral activity in vision appears to be based upon a similar relationship of volume and surface reactions suggests that the process of excitation which is a cube root or volume reaction represents the using

up of the cells of the nervous system, while recovery which is based upon a square root or surface reaction represents the rebuilding of cellular material or function for cerebral activity. The laws of cerebral activity in vision (and also in olfaction) therefore, appear to be similar to, if not identical with the laws of organic growth; they represent a similar process — catabolic as far as excitation, and anabolic as far as recovery for the effects of excitation are concerned. They suggest that central nervous system excitation and recovery are based upon a modification of the fundamental factors involved in organic growth. It would appear, then, as if *excitation of the central nervous system predominantly affects the entire mass of the functioning cells and is a volume or cube root reaction, while the recovery process is mainly based on a surface or square root reaction.*

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NOTES

DEATH - AN ADAPTATION

ALL living beings are direct descendants of others. Life is a single coherent natural phenomenon of which neither the beginning nor the end is known. It must be accepted as an entirety for there is no reason to assume that it may be composed of a group of similar, independent phenomena. As, generally, the end of life is not known, it is uncertain whether a natural death is inherent to life. On the other hand, it is rather easy to imagine how it may be terminated by destructive changes of the environment. Life on earth, for instance, might cease on account of excessive heat.

Natural death is not necessarily an attribute of life in general and, in agreement with this, the lowest organisms do not even show an individual natural death. In unicellular organisms the individual divides into two and by so doing ceases to exist; but, since there is no corpse, there is no death. All of the actual deaths of unicellular beings must be considered to be artificial, that is, caused by the environment.

It is also rather significant that in Vertebrates the individual as a whole may be subject to natural death but the separate cells are not, as is shown by tissue cultures which may be continued indefinitely.

Some plants, like *Senecio vulgaris,* germinate, blossom and bear fruit at all seasons. Yet, the duration of their life is about one year and so their organizations include a natural death. Other plants, like the sequoia trees, may reach an age of thousands of years. Some of their parts may die off but as individuals they seem to be able to live for ever, provided they are not hit by lightning or disease.

Having escaped artificial death, the majority of living beings die naturally and this impressive phenomenon seems to be an adaptation without which evolution would be impossible.

The occurrence of evolution follows from two considerations. Firstly, all life is derived from life. In regard to this, Pasteur removed the last scientific doubt. Secondly, not all organisms are fundamentally

the same. A dog and an oak tree are not only different because their germs have developed within a different environment but also because their germs are not alike. Consequently, if all life be one and yet the organisms essentially different, evolution must exist and apparently leads to greater complexity, better adaptation to environment and higher mental development.

Propagation and death are the conditions of this evolution. Without these, life on earth might continue indefinitely but none of the new organisms would have a chance to maintain themselves and hence evolution would cease. Even for the lowest organisms death is not destruction without any further significance. To die is to share a grand vital process: evolution.

Darwin's principle of the struggle for life already implies that artificial death is a factor in evolution. It seems that such death does not promote evolution sufficiently. Because everything new, however strong potentially, begins by being weak, the momentarily strongest and most adapted organisms might maintain themselves for ever if their life were without natural death and, therefore, indeterminate. This would prevent the continuation of evolution. The acquisition of natural death by the higher organisms may therefore be seen as a more perfect adaptation.

To a certain extent natural death is explained by its being recognized as an adaptation, because to explain is nothing but to substitute something more familiar for something less so. Yet, it is significant that in this way death is incorporated in a group of phenomena which more than others remain unintelligible.

The expression "To deserve death" may be regarded in a new light. The idea expressed above leads to the conclusion that only those organisms *deserve* death which are replaced by better ones. This may reconcile us with death. At the same time, it greatly emphasizes the utmost care for posterity. Thus, propagation and death are inseparable parts of evolution.

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RECENT LITERATURE

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